Board 375: REU Participants' Perceptions of Engineering Education Research: Looking for REU Impact

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Abstract

Undergraduate research has received growing attention in recent years due to its positive impact on engineering, including increasing students' understanding, confidence, awareness, and interest in numerous engineering subjects. Our research experience for the undergraduate (REU) program focuses on engineering educational research, which is to expose and train undergraduate students in emerging engineering education research through independent, collaborative well-managed, high-quality research projects.

This paper shares the findings of the REU participants' perception of engineering education research before and after participating in Engineering Education (EED) research projects. The qualitative data were collected through Qualtrics survey from three REU cohorts, those who participated in the summer of 2021, 2022, and 2023. Each cohort participated in a 10-week research activity and was mentored by experienced researchers at a mid-sized public university located in the western United States. There were 24 students (16 females, and 8 males) from 20 institutions across 15 different states, who participated in the program working on 13 research projects.

One of the questions found within the entry and exit surveys asked each participant to describe their perception of EED research. Two researchers were involved in the data analysis to find themes that identify the participants' understanding of engineering education research. About 88% of the participants claimed that their views on EED research have changed after participating in the program. Five themes were identified reflecting perceptions about EED research before and after REU participation. Further analyses based on gender, prior research experience, and educational background were also conducted. A brief discussion on how their research experience impacts their future study or professional career will be included in the paper.

Keywords: undergraduate research, engineering education research, change of perception

1. Introduction

Research activity that involves undergraduate students is one of the best approaches to improving student learning and has a positive lasting impact on students' career choices and success. A longitudinal research study to examine the benefits, outcomes, and goals for undergraduate research across disciplinary areas reported that there exists a positive association between undergraduate research participants and their long-term achievement when this positive association was measured by higher graduation rates and a higher number of national awards they received (Craney et al., 2011). The National Science Foundation (NSF) has been supporting undergraduate research that provides support for a cohort of undergraduates (six to ten per year) over a three-year project period (National Science Foundation, 2013). REU Site programs can be either a summer program (i.e., REU students conduct research in summer at the project PIs' institutions) or an academic year program (i.e.,

REU students conduct research throughout an academic year with the supervision of the project PIs).

The overall goal of our REU Site program is to motivate and retain talented undergraduates in STEM careers, particularly careers focused on teaching and STEM education research. The REU program is designed and implemented to promote three philosophies of work ethic that are found to foster quality intellectual research leadership: individual, collaboration, and project management leadership. This paper is submitted for poster presentation at the ASEE 2024 conference to display a better understanding of participating students' perceptions of EED research before and after a 10-week REU participation. In addition, some demographic information gathered was factored into the data analysis to see if those variables bear influences on those perceptions. Students' perceptions may be instrumental in influencing students' interest in EED research in the future and in pursuing advanced degrees and careers in teaching and engineering education research.

2. The Study

This study was conducted during the first three years of our REU-Site Program (i.e., Summers 2021, 2022 and 2023) at one public university in the western part of the United States. Due to the COVID-19 pandemic, the REU Summer 2021 (i.e., Phases 1 and 2, see details in the contexts section below) was conducted completely online through virtual meetings, discussions, collaborations, and reporting with their research mentors and fellow participating students. For some of the research projects during this first year, some students were required to purchase relatively inexpensive tools to help them work on their particular project. REU Summer 2022 and 2023 (i.e., Phase 2) was conducted in person at our campus. No tool purchases were required in this year.

2.1. Contexts

The REU summer program was 10 weeks long and was conducted in two phases: Phase 1 – Pre REU-Site Program (Weeks 1-2); and Phase 2-REU Site Program (Weeks 3-10). Phase 1 consisted of preparatory and foundational work that was delivered to participants online and allowed them to begin Phase 2 with some educational research foundation already established when they arrived at USU. It was strategically placed to ramp participants up, so they were more effective when beginning phase 2. During Phase 2, each participant worked on his or her project in a team at the USU campus.

Depending on the selected research project, REU participants acquire competency in developing and justifying research ideas, formulating research hypotheses, implementing a research plan; analyzing collected data; communicating and disseminating research results; and developing strong technical, professional, communication, and team-working skills. Each REU participant was provided with an office cubicle in a graduate student room to facilitate daily interactions between REU participants and the graduate student and faculty mentors. Each office cubicle was equipped with a desktop computer with Internet and printer connections. In addition, all REU participants had access to a multi-purpose room where they could discuss their research and collaborate with each other and graduate/faculty mentors throughout Phase 2.

The REU program recruited 24 undergraduate students (16 females, and 8 males) from 20 institutions across 15 different states that participated in the 13 separate research projects offered in the three summers (2021, 2022, and 2023) of this REU program. All participants worked in a team of two or three on a research project of their choice. Research projects were targeted to existing research conducted by Engineering Education faculty who provided primary mentorship to the participants. Secondary mentorship was conducted by graduate students assigned to those research areas under the engineering education faculty.

2.2. Research Question

One major research question was constructed to guide the study: How did a 10-week engineering education focused research activity change the perception of undergraduate students toward EED research? Further analysis was conducted to evaluate those changes, if any, based on some student's demographic information such as gender, prior research experience, and educational background.

2.3. Data Collection and Analysis

Data were generated and collected using an ad-hoc web-based survey tool called Qualtrics. An online survey was tailored and prepared in this software for the specific context of this study. The researchers developed, face-validated, and refined the survey items to meet the purpose of the study and to improve the readability. One entry and one exit survey were distributed to all REU participants of both cohorts. There were two original surveys administered to the participants, before and after the REU program, consisting of 24 items including 13 multiple-choice/multiple-answer and 11 open-ended questions. Two open-ended and some of the demographic items of the survey are relevant to this study and are shown in Tables 1a and 1b.

Table 1a. Three demographic questions

Category	**Available Responses**
Gender	• Female • Male • Not to disclose
Education Background	Opened-ended responses
Prior Research Experience	□ No □ Yes

Table 1b. Two open-ended questions were used in the study.

	Questions
Before REU Participation	What is your current perception of Educational Research?
After REU Participation	Have your perceptions about research changed after completing your REU program? In what way?

The Institutional Review Board (IRB) approved a research protocol used for this work and this approval was received before collecting and analyzing data. Students' participation in the

survey was voluntary, and they were allowed to opt out of participation at any stage of the survey completion process.

Due to the exploratory nature of this study, an inductive qualitative analysis approach was used to analyze the data and answer the research questions. Inductive approaches are more relevant in cases where existing theoretical concepts are not immediately available to help comprehend the phenomenon at hand. Twenty-four (24) responses corresponding to the two open-ended survey questions were qualitatively analyzed and coded in two cycles (i.e., first-cycle coding and second-cycle coding) to answer the research question. Some frequency count was also conducted to enrich the analysis.

During the first cycle of coding, researchers used descriptive coding to assign descriptive labels that summarized parts of the qualitative responses provided by REU students. In the second cycle of coding, emerging themes were identified using pattern coding/identification (Saldana, 2016). The first cycle (descriptive) coding was completed in four rounds. During the first round, two coders individually analyzed all collected responses to the two open-ended survey questions, one before and one after participating in the REU program. Both coders were provided with the list of student responses in an Excel worksheet. Each coder segmented and analyzed each student's response and noted descriptive codes in the form of words and short phrases opposite to that segment's cell. It is noted that some of the students' responses comprised multiple segments (each segment coded differently) and hence could tie to more than one code. It is necessary to note that open-ended responses from before and after the REU program did correlate to the codes.

In the second round of first-cycle coding, the two coders and two additional researchers discussed the initially identified codes together in order to develop a consensus on the identified codes and refine them for consistency and inter-coder reliability. Once the two coders, along with inputs from two additional researchers, agreed upon identified codes, the initial two coders revisited the coding in a third round to discuss coding and increase coder consistency.

The third round of first-cycle coding was conducted in isolation to avoid any coercion in deciding to accept or reject any codes. In the last round of first cycle coding, the coding conducted by the two individual coders was compared. Only those descriptive codes that were agreed upon by both coders and their respective data segments were considered for categorization, emerging themes, and discussion. During the second cycle of coding, the identified codes were categorized to identify emerging themes (patterns) that explained the phenomena concerning the research question and its interpretations.

3. Findings

The data used in this work (i.e., responses to the two survey items described in section 2.3.), consisted of 48 text-based responses, 134 segments, and 184 descriptive codes that addressed the students' perception of EED research before and after participating in the REU program reported. Demographic data for the 24 participants are presented in Table 2. Data shows that the demographic categories of female, engineering, and having prior research experience students were dominant for the majority (more than 50%) of the sample.

Table 2. Participant Demographic Information (n = 24)

Demographic Category	Number (% of Sample)
Gender	
Female	16 (66.67%)
Male	8 (33.33%)
Education Background	
Physical Science (S)	2 (8.33%)
Social Science (S)	3[a] (12.5%)
Technology (T)	0 (0%)
Engineering (E)	15 (62.5%)
Mathematics (M)	4[a] (16.67%)
Prior Research Experience	
No	12 (50%)
Yes	12 (50%)

[a] one student had dual majors of Mathematics and Social Science

There was a total of five themes that emerged from the analysis: three common themes that arose for both before and after, one emerging theme uniquely found only for before, and one emerging theme uniquely found only for after the REU participation (see Table 3).

Table 3. Five emerging themes

Emerging themes	Meaning
Utility of EED Research*	The usefulness of Engineering Education Research
Focus of EED Research^	The center of interest or attention of Engineering Education Research
Positions Toward EED Research*	Participants' attitude toward Engineering Education Research such as perceived importance for it to be done or its need or an increase or decrease in the same.
Inadequacy of EED Research*	Deficiency or shortcomings of Engineering Education Research in its abilities to address issues, or its methods to discern.
Approaches of Doing EED Research#	Plans and procedures of engineering education research which contains finding research questions, data collection, analysis, and interpretation

*Identified themes before and after participating REU program
^Identified themes only before participating REU program
#Identified themes only after participating REU program

Before participating in the REU program, students' perceptions about EED research could be categorized into four themes. They are *Utility* (rank 1st for popularly perceived), *Focus* (rank 2nd for popularly perceived), *Positions Toward* (rank 3rd for popularly perceived), and *Inadequacy* (rank 4th for popularly perceived) *of EED Research*.

There were 21 of the 24 students (i.e., 88%) claiming that they had perceived EED research differently than prior REU participation. One student (i.e., 4%) claimed no perception change and two students (i.e., 8%) offered no comments to the question (see Figure 1). After

participating in the REU program, three themes were previously identified, and one new theme emerged. They are *Position Towards* (ranks 1st for popularly perceived), *Approaches of Doing* (ranks 2nd for number of occurrences), *Inadequacy* (ranks 3rd for number of occurrences), and *Utility* (ranks 4th for number of occurrences) of EED Research. Additionally, an emerging theme of *Approaches of Doing EED research* was mentioned only after, and not before, participating in the REU program. Our findings also found that one emerging theme previously identified before participating in the REU program (i.e., *Focus of EED Research*) was not mentioned after the REU program by the students (see Table 4).

For the reader's benefit, the themes can be briefly defined in the following way.

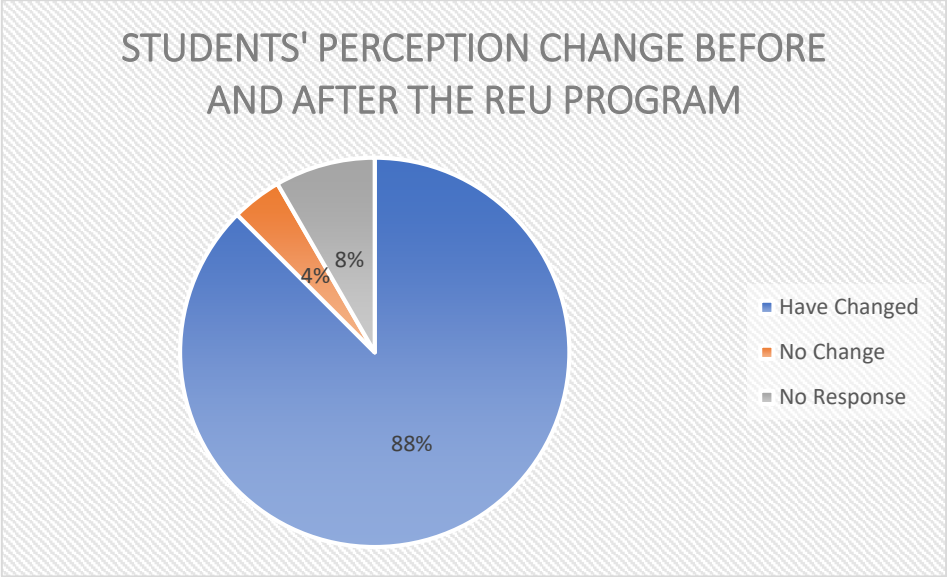

Figure 1. Perception changes before and after participating in the REU program

Table 4. Emerging themes: Student's perceptions about EED research before and after REU participation

Perception about EED research before REU participation	**Perception about EED research after REU participation**
[1]Utility of EED research (12 F; 4 M) (8 HE; 8 NE) (1 PS; 1 SS; 0 T; 9 E; 3 M)	[1]Positions towards EED research (18 F; 6 M) (10 HE; 14 NE) (2 PS; 3 SS; 0 T; 16 E; 3 M)
[2]Focus of EED research (10 F; 5 M) (8 HE; 7 NE) (0 PS; 1 SS; 0 T; 12 E; 2 M)	[2] Approaches of doing EED research (18 F; 4 M) (5 HE; 17 NE) (0 PS; 1 SS; 0T; 17 E; 4 M)
[3]Positions towards EED research (8 F; 3 M) (5 HE; 6 NE) (1 PS; 0 SS; 0 T; 9 E; 1 M)	[3] Inadequacy of EED research (3 F; 1 M) (2 HE; 2 NE) (0 PS; 1 SS; 0 T; 2 E; 1 M)
[4]Inadequacy of EED research (1 F; 1 M) (1 HE; 1 NE) (0 PS; 0 SS; 0 T; 2 E; 0 M)	[4]Utility of EED research (1 F; 1 M) (0 HE; 2 NE) (0 PS; 1 SS; 0 T; 1 E; 1 M)

Number of occurrences with first being highest and fourth lowest: [1] = first; [2] = second; [3] = third; [4] = fourth
Gender: F = females; M = males
Prior Research Experience: HE = have experience; NE = no experience
Education Background: PS = physical science; SS = social science; T = technology; E = engineering; M = mathematics

Our findings also show that before students participated in the REU program, two themes of, "focus of EED research" and "positions towards EED research," showed a much larger separation (i.e., greater than 50% gap between HE and NR experience) between those with than those without prior research experience. On the other hand, after REU participation, both students with and those without prior research experience showed similar patterns for perceptions of EED research.

Below are some examples of the excerpts for each emerging theme taken verbatim from the survey.

"I think that educational research should have a focus on the diverse lives of students and the individual situations they face daily that effect their current education in childhood or ability to participate in a higher education in the future." (Focus of EED Research)

"I have a very positive outlook on educational research" (Positions toward EED Research)

"I do not believe enough time and resources are allocated to educational research which explains why there is so much room for growth." (Inadequacy of EED Research)

"Performing Educational Research can help a student further develop critical thinking and problem-solving skills that are not as easily developed in a classroom environment." (Utility of EED Research)

"My understanding of literature reviews, their importance, uses, and how to synthesize information to create one all grew greatly. I learned how challenging it can be to formulate research and interview questions." (Approaches of Doing EED Research)

4. Conclusions and Brief Discussion

The REU program seems to be able to help students change their view on and understanding of engineering education research. During the program, the participating students learned of some of the many types of research found in the engineering education field as well as appropriate procedures for conducting that particular research. This exposure to engineering education research enabled students to understand and describe ways of doing that research (i.e., a new theme of *Approaches of Doing Research was introduced post REU exposure*).

The data analysis also indicates that the ranking for the occurrences of themes were changed when students were asked to describe EED research before and after exposure to the REU experience (see Table 3). Particular note is given to the first top two themes for post REU experience of *Positions toward EED Research* and *Approaches of Doing EED* Research. The first rose from having the least occurrences in the pre REU data to having the most in the post REU data. This is possibly a result of student's exposure during their REU experience to a limited scoped project focused on one area of engineering education research. It may also describe a realization of a project's ability to create smaller impacts in the community than the student may have previously thought and is likely a result of a reduction in naivety.

The latter emerged as a result of exposure to the REU and certainly reflects student's introduction to the process of engineering education research as well as social science research in general. It is almost certain that many of the REU students had no previous exposure to methods for developing research questions, or data collection, or analysis, etc. Additionally, a theme of *Inadequacy of EED research* also steps up to a third position

regarding occurrences from its pre REU position of fourth. Students may have developed a better sense of the capabilities of engineering education research after exposure to the REU. They may now be more finite in their understanding of where engineering education research can be applied, which shows a better critical evaluation capability in the participants regarding this type of work. It may also preclude an understanding to the specific methods that must be used in different research methods such as qualitative or quantitative or mixed methods. An example may be that students developed a better sense of the limitations to what a survey instrument can assess versus transcripted data. A better understanding of the methods needed for different types of research.

Utility of EED research moves from a pre REU position of first in occurrences to one of fourth in the post-REU data. This is an interesting finding and may be tied, again, to the realizations occurring in the REU participants that were just explained above. Finally, the *Focus of EED research* moves from an occurrence ranking of second in the pre REU data to not being in the top four rankings in the post REU data. It is possible that pre-conceived notions of what engineering education focuses on as a research community is no longer as prevalent in the student's minds after having been exposed to some of the work within it.

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