

# Virtual REU Program: Engineering Education Research

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## Virtual REU Program: Engineering Education Research

### Abstract:

This paper describes a National Science Foundation-funded Research Experiences for Undergraduates (REU) Site program conducted through virtual working environment. Due to the Covid-19 pandemic, REU 2021 activities were conducted online through Canvas and Zoom communication platforms. The major aim of this program is to provide undergraduate students with experiences in engineering education research (i.e., education research in the context of engineering). This paper provides an overview of the program, and briefly describes the virtual working environment, and students' research experiences during the 10-week program.

A total of 11 undergraduate students, seven graduate mentors, and seven faculty mentors have actively participated in the program. The program is conducted in two phases: Phases 1 (i.e., Weeks 1-2) and 2 (i.e., Weeks 3-10). Phase 1 consists of preparatory and foundational work that is delivered to participants and will allow them to begin Phase 2 with some educational research foundation already established.

The results of the project evaluation show that the program has made a positive impact on increasing education research skills and communication skills of the participating REU students. The participating REU students reported that the research projects they worked on increased their motivation and confidence for continuing to engage in engineering education research. Four participants (i.e., 36.4% of the total participants) suggested that, if available, they would prefer face-to-face over a virtual REU program. Another four participants (i.e., 36.4%) felt that both face-to-face and virtual would offer the same quality of research experiences, and 3 participants (i.e., 27.2% of the total participants) voiced their preference of virtual over face-to-face REU program.

**Keyword:** *undergraduate research; virtual working environment; research experience, engineering education*

### Introduction

Undergraduate research is an area of increasing growth in recent years due to its positive impact in STEM (science, technology, engineering, and mathematics) education. Its impacts include increasing students' understanding, confidence, awareness, and interest of STEM subjects [1-4]. Exposing undergraduate students to research experiences enhances intellectual skills such as inquiry and analysis, reading and understanding primary literature, communication, and teamwork.

The main objective of this REU site program is to develop knowledge, broaden participation, and improve teaching and research practice in the field of engineering education. It is also expected that this program could stimulate REU participants' interest in pursuing graduate degrees and careers in teaching and STEM education research. To achieve that objective, the proposed REU Site Program is conducted in two phases during a 10-week time. Phase 1 is conducted during the

first two weeks to prepare the participants in the research work that occurs during Phase 2, which is the actual research work involved with data preparation, analysis, understanding results, and developing conclusions from those results. It is strategically placed to ramp participants up so they will be more effective when beginning phase 2.

Applicants are initially requested to select and rank the top three projects they are most interested in with brief description of the rationale of their selections. The PI/Co-PIs of the REU program, together with the Faculty mentors, then meet to make the final decision on project assignments based on students' ranking, rationale, and the faculty mentors' evaluation of the students' application package.

Due to the Covid-19 pandemic, the REU 2021 activities were conducted online through Canvas and Zoom communication platforms. A well-designed and dedicated Canvas site was developed to bring a new learning and working environment to remote students for both Phases 1 and 2. Recent "best practices" disseminated by NSF for online REU's were incorporated into the REU program for this online experience.

### **Participants, Activities, and Working Environment**

There were 56 applications received and 11 participants were selected and invited to participate in 2021 Summer REU program. Thirty-four applications were complete and included all required documents. Among 34 valid applicants, 18 (53%) are females and 16 (47%) are males. The total number of female or racial minority (e.g., Hispanic, Black, Asian) applicants are 32, accounting for 57% of all complete applications. Thus, this REU Site program exceeded its recruitment goal in terms of recruiting a significant number of female and racial minority students. Among these 11 selected participants, 6 female and 5 male undergraduate students from nine states and a variety of educational backgrounds were accepted.

The program began on May 18 and ended on July 22, 2021. Phase 1 was conducted in the first two weeks, from May 18-28; and Phase 2 was conducted from May 24 to July 23. During Phase 1 (Weeks 1 and 2), all participants participated in a welcoming virtual zoom meeting as well as participating in five workshops. Additionally, they were asked to read two readings to prepare them for Phase 2. The five workshops attended by participants were Workshop 1: Literature Review and Organization; Workshop 2: Research Ethics - Focusing on publication and authorship; Workshop 3: Curriculum and Research: Developing an Educational Research Question; Workshop 4: Mixed Methods Research Methodologies with Emphasis on Qualitative; and Workshop 5: Educational Data Analysis with SPSS. Relevant just-in-time mentorship, such as immediate feedback on student coding questions, or quick reminder demonstrations on using software analysis programs such as SPSS were conducted in Phase 2 via a variety of online methods.

During Phase 2 (Weeks 3-10), all participants were working on their own respective project under the mentorships of 1 or 2 faculty research mentors and 1 or 2 graduate research mentors. All, except one, of those participants were working on a group of 2 or 3 participants. There were five research projects available to work on for this year (see Table 1).

Table 1. Research Projects and Participants

| Research Project Title                                                                                                                                                                                        | Research Method Employed | Number of Participants |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------------------|
| Adaptation and Learning Strategies in Unplanned Unexpected Learning                                                                                                                                           | Mixed method             | 2                      |
| Understanding the Impact of Expanding Statics Problems towards Environmental and Biological Engineering Applications                                                                                          | Mixed method             | 2                      |
| Effects of Participation in High Impact Educational Practices (HIP) on the Persistence and Success of Engineering and Computer Science Students                                                               | Qualitative method       | 1                      |
| Mobile Instructional Particle Image Velocimetry (mI-PIV): Using Mobile Devices to Improve Student Interest in and Perceptions of Learning Fluid Mechanics via Hands-on Flow Visualization and Experimentation | Qualitative method       | 3                      |
| Engineering Identity                                                                                                                                                                                          | Qualitative method       | 3                      |



Figure 1. REU 2021 Front Canvas Page

During Phases 1 and 2, each participant was asked to submit bi-monthly quick reflection online. In all projects, in addition to doing research, each participant was given the opportunity to learn and engage in the initial draft of a conference (or journal) manuscript. An extended “Literature Review and Organization” workshop (i.e., Workshop 1) was conducted during the Week 9 to further support the participants’ writing skill. Moreover, each participant submitted a final report that described lessons learned during the 10-week program.

This online ten-week REU program was conducted at the participant’s home or internet

capable area, via internet and computer access, and facilitated by USU’s Canvas learning management system and other online communication media (see Fig. 1 and Fig. 2). Interactions among participants, graduate/faculty research mentors, and supporting staffs were conducted through those online media.

## What did the Participants Say about Their Research Experience?

We conducted pre- and post-assessments to understand the participants' perception about education research and the value of education research in engineering, and to discover gaps between expectation and actual research experience that they gained from the program. Due to the large number of data

collected and the analyses which is still currently in-progress, only findings from selected survey item of the post-assessment are discussed in this paper.

Twelve closed-ended questions were included in the post-assessment (Table 2). Likert scales used to capture participants responses on the items ranged from Strongly Disagree (SD), Disagree (D), Agree (A), and Strongly Agree (SA).. The reader will note that most of the responses on these 12 items are either in the "agree" or "strongly agree" categories.

Table 2. Twelve closed-ended post-assessment items ( $N= 11$ )

| #  | Statements                                                                                                       | SD        | D          | A          | SA           |
|----|------------------------------------------------------------------------------------------------------------------|-----------|------------|------------|--------------|
| 1  | Phase 1 of the REU program was well-organized                                                                    | 0<br>(0%) | 0<br>(0%)  | 2<br>(18%) | 9<br>(82%)   |
| 2  | Phase 2 of the REU program was well-organized                                                                    | 0<br>(0%) | 0<br>(0%)  | 4<br>(36%) | 7<br>(64%)   |
| 3  | I have gained useable knowledge and will be able to apply it for future professional work                        | 0<br>(0%) | 0<br>(0%)  | 0<br>(0%)  | 11<br>(100%) |
| 4  | The journal reading assignments in my project have improved my research skills                                   | 0<br>(0%) | 0<br>(0%)  | 4<br>(36%) | 7<br>(64%)   |
| 5  | I felt that my "Bi-monthly Reflections" activity was helpful for me to identify the value of research experience | 0<br>(0%) | 1<br>(9%)  | 6<br>(55%) | 4<br>(36%)   |
| 6  | The time available for Phase 1 was adequate for an REU program                                                   | 0<br>(0%) | 0<br>(0%)  | 2<br>(18%) | 9<br>(82%)   |
| 7  | The time available for Phase 2 was adequate for an REU program                                                   | 0<br>(0%) | 2<br>(18%) | 6<br>(55%) | 3<br>(27%)   |
| 8  | The five workshops that were delivered in the REU were useful                                                    | 0<br>(0%) | 1<br>(9%)  | 4<br>(36%) | 6<br>(55%)   |
| 9  | The workshops conducted during Phase 1 were well-designed and delivered                                          | 0<br>(0%) | 1<br>(9%)  | 3<br>(27%) | 7<br>(64%)   |
| 10 | I would recommend this REU experience to a friend                                                                | 0<br>(0%) | 0<br>(0%)  | 1<br>(9%)  | 10<br>(91%)  |
| 11 | The faculty research mentor(s) were helpful in facilitating my research experience                               | 0<br>(0%) | 0<br>(0%)  | 1<br>(9%)  | 10<br>(91%)  |

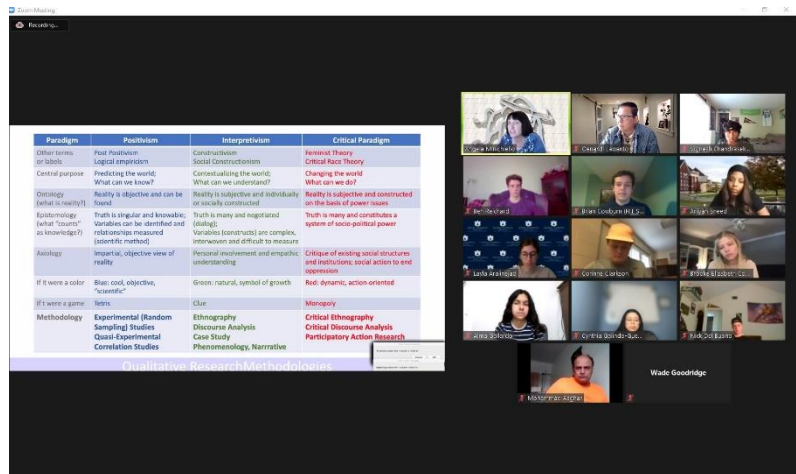


Figure 2. One example of a virtual workshop during Phase 1 REU program

|    |                                                                                             |           |           |            |            |
|----|---------------------------------------------------------------------------------------------|-----------|-----------|------------|------------|
| 12 | The graduate student research mentor(s) were helpful in facilitating my research experience | 0<br>(0%) | 0<br>(0%) | 2<br>(18%) | 9<br>(82%) |
|----|---------------------------------------------------------------------------------------------|-----------|-----------|------------|------------|

When asked if the virtual REU experience was felt to be better, the same, or worse than a face-to-face REU experience. The majority of participants showed positive (i.e., 7 participants or 63.6%) responses toward the virtual REU (i.e., better or the same). Below are some of the responses in verbatim (Table 3).

Table 3. REU participants responses: Is virtual better than face-to-face REU program?

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Virtual is better than face-to-face REU program                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| <ul style="list-style-type: none"> <li><i>I consider this to be better, I personally chose this internship because I wanted something online so I could stay at home and even get another part time job if possible. I also found that communication was overall well done so that didn't cause any issues.</i></li> <li><i>I think this research experience is much better online, because I did not have to travel from home, and I was able to keep my summer job. Also, being at school for a full year and then going away for a summer project seems intense, and I feel like it was less intense working from home.</i></li> </ul>                                                                                                                                                                                                             |  |
| Face-to-face is better than virtual REU program                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| <ul style="list-style-type: none"> <li><i>I do not have a reference to compare my experience to a face-to-face REU; however, I have looked at the schedule that the previous REU programs followed while they were face-to-face and I would consider the in-person experience to be more engaging. It is certainly easier to connect with others when working in person, and while I was able to develop a good relationship with my mentors and the meetings were still engaging, I still consider I learn better in face-to-face environments.</i></li> <li><i>I would say online REU experience is worse than face-to-face. This is simply because we are human beings that work better with others around us. Especially in research when you cannot sit down face-to-face with your team it can be struggling to find motivation.</i></li> </ul> |  |
| Virtual and face-to-face REU program offer the same research experience                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
| <ul style="list-style-type: none"> <li><i>I believe it is both better and worse in different aspects. It is better because I was allowed flexibility. However, it is worse because I wasn't able to connect with my peers in person and do hands on activities.</i></li> <li><i>The same. Although we would all obviously prefer to be in person, I think that the REU experience was the best that it could have been virtually! I really enjoyed being online despite wanting to be in person, but that's life!</i></li> </ul>                                                                                                                                                                                                                                                                                                                      |  |

## Conclusions

This virtual REU program has observed a positive impact on the development of undergraduate engineering education research. In this project, REU students actively participated in five specially designed research projects that share a common intellectual focus of problem solving in engineering education. Our REU research projects addressed different problem-solving topics. Our REU research projects filled a significant knowledge gap by focusing our research efforts in engineering education, a discipline receiving growing attention in recent years as industries have set up growing demands for high quality engineers.

Through intensive research and mentoring activities, this virtual REU program provides the participating students a significant number of training and development opportunities. All

participants have developed initial drafts of papers that are being or will soon be submitted for conference or journal publications. These REU students represent individuals who will be the future STEM workforce. The success of their professional career helps contribute to the prosperity of our nation. Additionally, the REU experience allowed a new generation of graduate mentors and one postdoc to develop experience teaching research concepts, data analysis, etc. online. This REU experience will also help them enter the workforce better prepared for similar situations that may force education to online settings.

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