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Reflections from Virtual Undergraduate Summer Research Experience with Interdisciplinary Teams

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1.0 Introduction

Like many Research Experience for Undergraduates programs around the country, in response to the COVID-19 pandemic, the REUs at this historically Black college in the Southeast transitioned its programs to a virtual format in the summer of 2020. This paper reviews and reflects upon data we collected from the REU undergraduate participants, and participants in a broader summer research program, the Summer Research Institute (SURI).

Our STEM faculty have been hosting undergraduate research about 10 years. Since the summer of 2017, we have been working to adopt critical pedagogy into our undergraduate student research experiences through carefully designed problems and activities. However, in the summer of 2020, due to the COVID-19 pandemic, the program had to be transitioned into a virtual research experience. In this study, we reflect on our experiences as supervising faculty, and the results of pre- and post-experience surveys completed by four groups of undergraduate researchers. In contrast to previous years' REUs, team interactions were not possible in the virtual environment, and activities were mainly training programs. Students were able to work with previously collected real data and write code. The participants' final presentations were technically better than those in the previous two years. Regarding the development of so-called soft skills, student engagement, team working skills, peer-to-peer interaction, and the overall experience was disrupted significantly.

Our experience of adapting the REU to a virtual environment was consistent with other recent literature. Chin (2020) reports that, as in many such programs, the alternative virtual REU was designed quickly. The resulting program included larger numbers of participants and greater diversity participants (10 on campus versus 700 virtual around the world), incorporating computational as opposed to hands-on research, with additional load on mentors. In another virtual REU experience (Dalbotten et al., 2020), researchers with hands-on backgrounds in sustainable land and water resources hosted a transformed experience. Feedback from the experience was similar: The REU included larger numbers of participants, collaboration among more diverse teams, computational topics, and utilization of previously collected data. Ashcroft et al. (2020) also discussed the larger community college impact of remote REUs before the full impact of COVID. Another virtual REU example (Cadena et al., 2020) included diverse applications and poster presentations.

2.0 The Interdisciplinary Research Experience for Undergraduates

For the past two summers (2018 and 2019), groups of students from a Historically Black College in the Southeast participated in a problem-based learning journey in the context of studying about autonomous vehicles. One of the long-term goals of this project was to prepare students, who are underrepresented minorities, for careers in intelligent transportation systems. Students have been part of a multi-disciplinary, eight-week summer research experience that integrated curricular and extracurricular activities. Very briefly, workshops, trainings, site and lab visits, hands-on data collection and sensor involved research on campus and on other university campuses targeted critical skills with a problem-based learning approach. The students also participated in a series of critical thinking sessions presented by the project team on defining a research problem, literature search, and the research process (Pierce et al., 2019, Comert et al., 2020).

The numbers of participants in past two summers were 8 and 7, respectively. The students were teamed in multidisciplinary groups. Initially they were given a relevant larger problem and then were grouped into subproblem teams based on their interests and majors. They participated in multiple activities that introduced them to the skills needed to solve part of such subproblems. Feedback from the students was positive. Their learning activities were designed to their levels of knowledge and skill, yet related to the larger research problem. Results from both summers presented what they were able to solve within their 8-

10 week experiences. Because there was no room and board to pay for, we were able to accept larger numbers of participants than in previous years.

During the first year's REU program (summer 2018), the students were given tasks to find and read relevant literature and software tutorials, to write scripts in R on machine learning algorithms, and to write a script for basic algorithms in Python to control smart cars. The second year's REU (summer 2019), consisted of a group of 7 research students. The students investigated vehicle platooning and biomimicry, computer vision, and sensor fusion on a problem defined as "Energy saving and emission reduction by platooning".

During the summer of 2020, we decided that it was very important to continue to provide research experiences to the students, despite the pandemic. We accepted as many students as we could, from a variety of funding sources available at the College. These programs included programs from the National Science Foundation, The Established Program to Stimulate Competitive Research (EPSCoR), the US Department of Transportation's University Transportation Center (Center for Connected Multimodal Mobility), and the US Department of Education. In Table 1, our participating students' majors, classifications, and their experience in REUs are listed. A total of 16 students from the Computer Science, Physics, and Engineering department were accepted.

Table 1: Summer 2020 REU Program Participants

Student	Major	Class	In the Project
1	Computer Science	Senior	3rd Year
2	Computer Science	Sophomore	1st Year
3	Computer Science	Junior	1st Year
4	Computer Engineering	Senior	3rd Year
5	Computer Science	Senior	2nd Year
6	Computer Engineering	Junior	1st Year
7	Computer Engineering	Junior	1st Year
8	Computer Science	Junior	1st Year
9	Computer Science	Senior	3rd Year
10	Computer Science	Junior	2nd Year
11	Computer Science	Junior	2nd Year
12	Computer Science	Junior	2nd Year
13	Computer Science	Sophomore	1st Year
14	Transportation Engineering	Senior	1st Year
15	Computer Engineering	Junior	1st Year
16	Electrical Engineering	Junior	2nd Year

2.1 Explore

During the 2020 REU, the students engaged in a set of lessons designed to help them develop needed technical and conceptual skills (mainly programming in Python and R). In addition, they participated in regular online workshops with topics including research and ethics, preparation of effective presentations, and graduate school application preparation. Table 2 summarizes the topics covered in the learning activities and workshops undertaken by the participants.

Table 2: Learning activity topics covered during the summer 2020 REU Program

Group	Field	Skills/Concepts
1	Communications, Transportation	5G, mathematics, Matlab
2	Computer Science, Transportation	deep learning, Python, OpenCV

3	Environmental Eng., Computer Sc., Transportation	deep learning, sensors, data collection, Python-Colab
4	Computer Science, Transportation	deep learning, data processing, filtering, Python-Colab
5	Transportation, Computer Science, Statistics	AADT, queueing, traffic speed, prediction, reinforcement lerning
6	Computer Science, Medicine, Statistics	Outbreak detection, machine learning, classification, R
7	Computer Science, Transportation	Kalman filter, Particle filter, queueing, parameter estimation
8	Transportation	Public transportation, COVID impact
9	Computer Science, Transportation	Cybersecurity, Bayesian detection, CUSUM, EM, R

2.2 Engage

During the 2020 REU, mentors from transportation engineering, mathematics, electrical engineering, and computer science advised the students within the broad topics listed in Table 3. Because of the increased number of participants, advisors' loads were higher in 2020 than they had been previously, so mentoring time per student was reduced.

Table 3: Groups of the summer 2020 REU Program

Group	Topic	Number of Students
1	5G Communications	2
2	Computer Vision	3
3	Air Quality	2
4	Safety	1
5	System State Estimation	3
6	Detection	1
7	Filtering	2
8	Design	1
9	Cyber Attack Detection	1

Regular meetings between students and mentors were conducted virtually using the College's official course meeting platform. Here are some general observations from the groups' approaches:

- Initially, students met with their advisors daily to get introduced to the problems, software, online coding platforms, and data that they would be using. Table 2 summarizes detailed concepts and items introduced.
- All SURI mentors presented their research plan on the first day of the summer research.
- Students either singly or in groups researched their problems. As shown in Table 3, we had 5 teams and 4 individual researchers. In fact, except groups 6, 8, and 9, other individual researchers are just changed the data. Groups 3, 4, and 5 essentially applied deep learning to their own data on air quality, safety, and traffic parameters.
- Each week, the students were introduced to new machine learning topics, participated in update meetings, and a Friday journal meeting with all SURI participants to present their progress and see the other teams' progress.
- Students shared their progress in a 20-minute multiple slides presentations.

- The program ended with a 10 minute, one slide presentation.

2.3 Experience

From the experience, results of the groups were mixed, depending on several factors. Good progress with a draft paper was obtained in one group. This group had met regularly. Two students worked on the same problem sharing responsibilities. Advisor's full commitment was needed. Another student was able to write a manuscript from the application and good results were obtained. Apart from student's focus, this is due to low amount of data (50 observations with about 7 numerical variables) as control was easy over results. One of the single-student teams focused rather literature and design. The student's progress led to a good presentation with a possible continuation as capstone design project. All deep learning models produced estimation models. Error levels were satisfactory compared to regression models. Filtering project using Kalman and Particle filters had progress but were not fully completed. One student graduated by the end of program, the other student held the study at the College. These would be the cause of thinking continuation plans not necessarily on campus. Cybersecurity team also produced a final report with a good progress.

2.4 Evaluate

Using the virtual format, students were able to continue to engage in undergraduate research in 2020, which would otherwise have been unfeasible. This provided continuity for promising students who otherwise would not have been able to develop their knowledge and skills through the summer. Although the team-building aspect of the experience was limited, there were opportunities for students to collaborate using the college's virtual platform.

From the faculty's point of view, the major drawback of the virtual experience was the difficulty in monitoring and guiding the student-participants. It was difficult to track their focus and engagement level. In general, the faculty mentors felt that the levels of engagement and peer-interaction were diminished. In their responses to the survey, the students themselves indicated that they may not have made as much progress as they could have in an in-person environment. Students needed reliable internet and access to software remotely. Latter required set up time with information technology department.

Apart from negative sides, there were also positive points. We were able to process and discuss data, coding, and using cloud-based development environments. Students were able to communicate day and evening without waiting for next day. These experiences also expose the students to be able to take tasks and individually complete and communicate with other team members formally. Communications usually required a graph, write up, or a presentation slide.

2.4.1 REU student participant surveys

Surveys were administered to participating SURI research experience students at the beginning of their summer research experiences (late May/early June 2020), and again at the end (mid-July). Because of the COVID-19 pandemic, and unlike past years, the students participated online via computer. 16 students completed the pre-experience survey, and 9 completed the post-experience survey.

2.4.2 Pre-experience survey items

The pre-experience survey consisted of 21 items, including 18 Likert-scale, and 3 open-ended items. The post-experience survey had 11 items with 4 closed-ended and 7 open-ended items. Pre- and post-experience items were not directly parallel, so it is not possible to measure change in the participants' perceptions and opinions based on these two surveys.

The Likert-scale items on the pre-experience survey included statements about learning preferences, teamwork, and research skills. In general, the students said they were quite confident in their ability to carry out their projects, and their preferences indicated an interest in learning through research.

Table 4: Pre-experience participant learning preferences and plans (N = 16)

	Mean Response*	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
I prefer to work on open-ended problems with many possible solutions.	5.19	0.0%	0.0%	0.0%	12.5%	56.3%	31.3%
I prefer to work on problems with a single correct solution.	4.06	0.0%	12.5%	12.5%	43.8%	18.8%	12.5%
I prefer to learn by hands-on experience, compared to typical classes.	5.44	0.0%	0.0%	6.3%	0.0%	37.5%	56.3%
I prefer working in a team when tackling a difficult research problem.	5.13	0.0%	6.3%	0.0%	6.3%	50.0%	37.5%
I am confident that I can learn what is necessary to solve research questions.	5.31	0.0%	0.0%	0.0%	12.5%	43.8%	43.8%
Having research experience will have a positive influence on my classes next year.	5.69	0.0%	0.0%	0.0%	6.3%	18.8%	75.0%
I am interested in a career that is related to the research I will be doing this summer.	4.69	0.0%	6.3%	6.3%	25.0%	37.5%	25.0%
After my bachelor's, I plan to pursue a master's or doctorate degree.	5.56	0.0%	0.0%	0.0%	0.0%	43.8%	56.3%

*Mean response where "Strongly Disagree" = 1 and "Strongly Agree" = 6

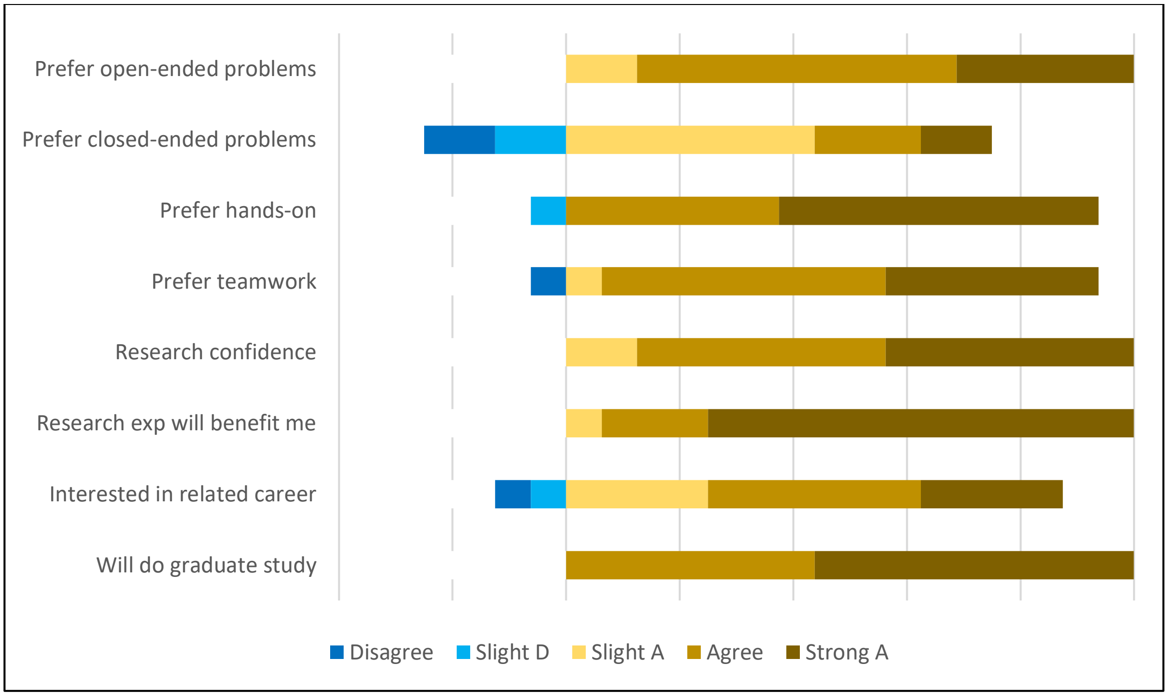

Figure 1: Pre-experience learning preferences and plans

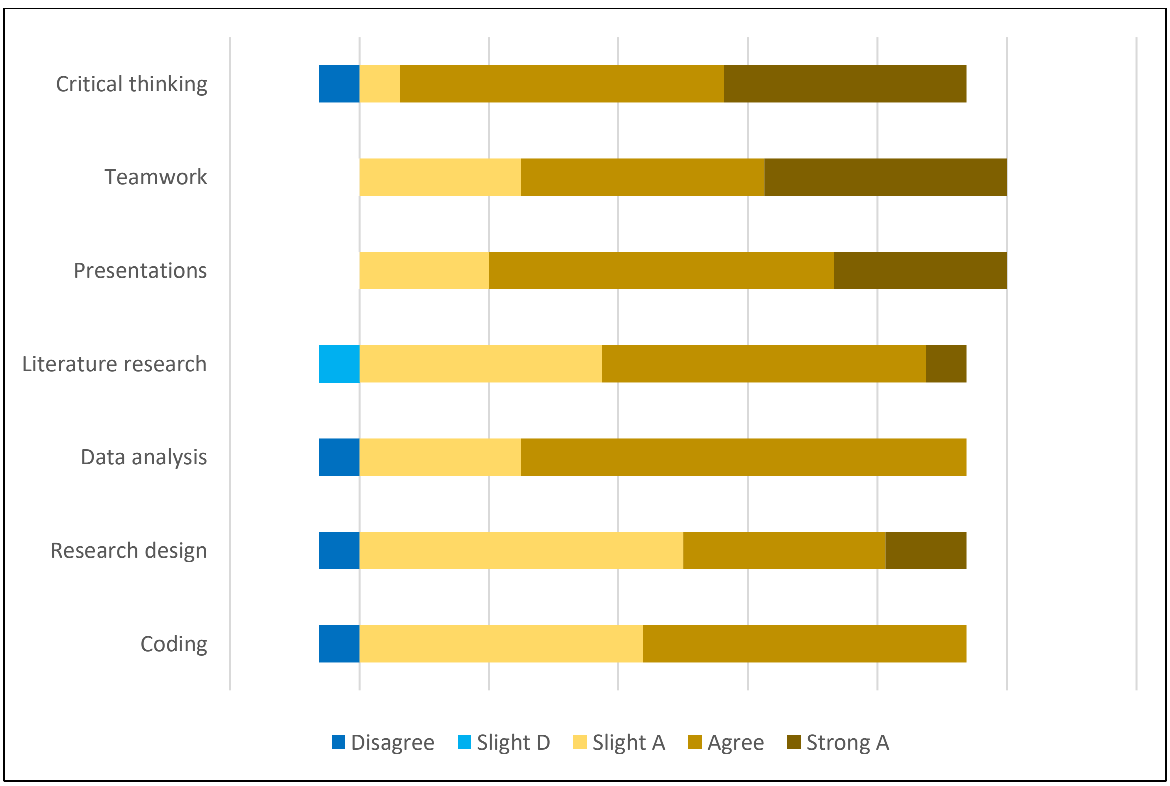

Figure 2: Pre-experience self-assessed research skills (sorted highest to lowest)

Table 5: Pre-experience participants' self-assessed research skills, highest to lowest (N = 16)

	Mean Response*	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
I have well-developed critical thinking skills.	5.13	0.0%	6.3%	0.0%	6.3%	50.0%	37.5%
I am good at working on team-based projects.	5.13	0.0%	0.0%	0.0%	25.0%	37.5%	37.5%
I know how to present and communicate research results.	5.07	0.0%	0.0%	0.0%	20.0%	53.3%	26.7%
I have well-developed skills in finding and understanding research papers.	4.56	0.0%	0.0%	6.3%	37.5%	50.0%	6.3%
I have well-developed data analysis skills.	4.56	0.0%	6.3%	0.0%	25.0%	68.8%	0.0%
I have well-developed skills in designing research studies.	4.44	0.0%	6.3%	0.0%	50.0%	31.3%	12.5%
I have well-developed coding skills.	4.38	0.0%	6.3%	0.0%	43.8%	50.0%	0.0%

*Mean response where "Strongly Disagree" = 1 and "Strongly Agree" = 6

2.4.3 Summary of responses to pre-experience open-ended questions (16 responses)

Shown are the main categories of responses, how many responses included statements in each category, and typical examples of these responses. Note that many responses were coded in two or more categories.
What are you most looking forward to with regard to this research experience? (Skills, contribution to literature and others.)

- To gain skills (10 mentions)
    - *…to see how independently I can do research*
    - *This research experience will improve my skills and understanding of related CS topics.*
- To improve knowledge in my discipline (7 mentions)
    - *By the end of the research, I want to…increase my knowledge in the field I am working at…*
    - *Learn new things relevant to my major…*
- Gain research experience (5 mentions)
    - *Learning and researching something new*
    - *I'm looking forward to the knowledge and experience that this will give me.*
- Develop skills in writing research for publication (2 mentions)
    - *I would like to develop a research that can be published in terms of Public Transportation and COVID-19*
- Application of knowledge from classes (1 mention)
    - *…applying what I learned in my classes*

What do you think will be most difficult or challenging with regard to this research experience?

- Need to learn new things (6 mentions)
    - *Trying to understand some concepts that I'm not familiar with at all*

    - *I think the most difficult part will be getting a good grasp on the concept of my group research topic.*
- Lack of in-person or hands-on experience (4 mentions)
    - *I think the fact that the research is virtual may be challenging*
    - *I think the fact that we will not be working in campus and not being able to work in the laboratory*
- Getting started (1 mention)
    - *It is just hard to get started, and knowing how to operate with the team but it gets better with time.*
- Virtual experience makes it harder to collaborate (1 mention)
    - *Not able to share opinion with the project members when we need them instead we focus on our part only which is a good thing but it motivates knowing what others thinking.*
- Other challenges (3 items)
    - *Request the data needed to create an accurate model*
    - *The most difficult challenge to my research is making sure that the Deep Q learning programs are debugged and properly rebuilt.*
    - *Technical difficulties sometimes*
- Not anticipating any challenges (1 mention)
    - *I don't really think anything would be challenging.*

What differences do you predict with on campus SURI program (considering this version as off campus)? Advantages and disadvantages please.

Advantages:

- Flexibility of work schedule (6 mentions)
    - *Whereas off campus is more time friendly since it gives the opportunity to work in our own time except for a few conference calls and meetings.*
    - *The advantages of off campus SURI program…would be that we are able to set a pace to work from, and quickly submit research online in a timely fashion.*
- Ease of communication with team and advisor (3 mentions)
    - *Advantage is easy to communicate with my advisor.*

Disadvantages:

- Lack of face-to-face interaction, leading to more difficult communications (8 mentions)
    - *It'll be harder with communication and learning for me since I am a hands on in person learning type of person.*
    - *A disadvantage would be the lack of communication. Hopefully, it won't happen*
- Lack of hands-on experience in a laboratory (4 mentions)
    - *for the disadvantages is the fact that we can't interact with other students or work in the laboratory*
    - *I think virtually learning this information will make us have to think differently to understand because we don't have the hands on experience.*
- Difficulty coordinating when participants are in different time zones (1 mention)
    - *In the [sense] that some people's time zone might be different from others, and the set time to get works done need to be properly analyzed as to avoid delay in delivery.*
- There are more distractions off campus (1 mention)
    - *On campus it's easier to not be distracted than off campus…*

2.4.4 Post-experience survey items

The four Likert-scale items asked the students to assess the research experience, and whether it had influenced their plans for graduate study. All responses were very positive (a rating of 4 or 5 on each item).

Table 6: Post-experience perceptions of SURI participants (N = 9)

	Mean	Least 1	2	3	4	Strongest 5
As 5 being very successful, how successful was the research experience overall learning new materials and methods?	4.89	0.0%	0.0%	0.0%	11.1%	88.9%
Again 5 being strongest, how much the research experience increased your self efficacy towards research and continuous learning?	4.67	0.0%	0.0%	0.0%	33.3%	66.7%
As 5 being very likely, given chance and you continue at the College, how likely you would like to continue research on this or similar topics?	4.67	0.0%	0.0%	0.0%	33.3%	66.7%
As 5 being strongest, how this experienced improve positively your graduate degree pursue probability in the future?	4.44	0.0%	0.0%	0.0%	55.6%	44.4%

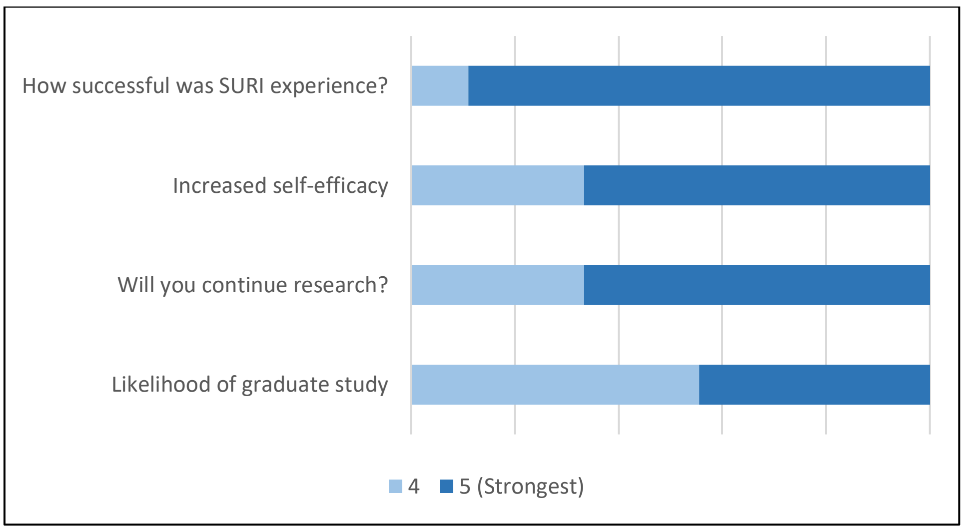

Figure 3: Post experience perceptions of SURI 2020 participants

2.4.5 Summary of responses to post-experience open-ended questions (9 responses)

Shown are the main categories of responses, how many responses included statements in each category, and typical examples of these responses. Note that many responses were coded in two or more categories.
In one sentence how would you define the problem you're worked on this summer research?

- Descriptions of the problem
  - *My summer research was based on data training.*
  - *I worked on AADT estimation on non-coverage road using deep learning.*
  - *Predicting Air quality using machine learning*
  - *Using different filters to estimate queue length in vehicles.*

- *A great topic applying decision making skill to a machine.*
- *In a condition of a traffic intersection, how can the traffic signal observe data from provide by the probe vehicle be utilize that doesn't not interrupt the flow of traffic.*

- Characteristics of the problem
  - *Challenging*
  - *Interesting*
  - *My research problem was an interesting development for the near future.*

What was the most important thing you learned from this research experience?

- Specific item or knowledge (3 mentions)
  - *I learn about the importance of filters and how you can apply them.*
  - *Better working with python and machine learning projects.*
- Doing research in a virtual environment (3 mentions)
  - *The most important thing that I learned was how important background research and learning the basics of complex topics are.*
  - *I learned how much being in person when doing research is important.*
- Insights about research (1 mention)
  - *To keep researching*
- Personal qualities (1 mention)
  - *I learned persistence and improved my research skills*

Were you able to achieve the final goal of the project? If not, what were the main challenges?

- Yes (6 mentions)
- Partially (2 mentions)
  - *Yes and no, we need to go in depth with the filter information to utilize them more in the code.*
- There is still more work to do (4)
  - *We have got the results we desire but there is still more to do with the project*
  - *We reached our short term goals but plan to continue our work.*
- Main challenges (1 mention)
  - *the main challenge was finding resource some might be a very high level*

How you would compare this online research experience with an on-campus research experience? Please list or discuss positive and negative sides.

Positive aspects:

- It was a good experience (3 mentions)
  - …I'm glad I was exposed to it being that my graduate program will be online.
  - It was a great experience.
- Work schedule was flexible (2 mentions)
  - I like how the online research times [are] flexible
- Appreciated being safe from COVID-19 (1 mention)
  - …based on the current circumstance has a positive side being safe

Negative aspects:

- Less face-to-face interaction (4 mentions)
  - *Negative: you do not get the same interaction from instructor and team members*
  - *The only difference [between the virtual and in-person experience] was not being able to have in person guidance from my mentor but we did our best using the virtual softwares.*

- Communication difficulties (2 mentions)
  - *…I believe that my note taking when listening to my group would have been better in person. I also feel that asking questions would be better in person but the virtual aspect did improve our communication skills with each other because we had to work slightly harder to communicate effectively.*
- Less hands-on experience (1 mention)
  - *I'm a hands on person so this was a struggle for me…*

If online research to continue, what would be some ways that we can improve it? How would advisors can help students better?

- Provide more resources (3 mentions)
  - *since we have to search everything online its better if we can get access or sponsor to paid sites*
  - *Give more organized notes for our research objectives*
  - *Providing more resources will be helpful*
- Tasks should be more structured (2 mentions)
  - *By assigning weekly tasks.*
- Require students to post to discussion boards or online communities (2 mentions)
  - *Being more active in the group discussion board and posting every day or weekly*
  - *To have a good virtual environment it would be great if there are virtual communities for students*
- Communication with advisors and monitoring progress (2 mentions)
  - *Effective communication from both sides is crucial.*
  - *Keep up with communication on the progress of students work.*

Have you enjoyed researching and would you consider a graduate school or research related career after you graduate?

- Yes (7 mentions)
- Individual comments (3 items)
  - *I have gained useful knowledge on which career I want to pursue and its data science*
  - *Yes definitely SURI has taught me how to do independent*
  - *I have enjoyed researching this summer and attending graduate school is my plan for the near future.*

Please list five things that you have learned from this experience which will impact your career or studies positively?

- Working with data (4 mentions)
- Communicating research results (3 mentions)
- Virtual interpersonal communications with research team (3 mentions)
- Python coding (2 mentions)
- Reviewing and reading research literature (2 mentions)
- Time management and related skills (2 mentions)
- Personal qualities (Patience, persistence, practice) (2 mentions)
- Using specific software (1 mention)

3.0 Future Directions

As with many REU programs, we found the virtual experience to be a disruption to planned and structured experience, and program's progress. Our intention was to continue the work we had begun in 2018 and 2019. Our original agenda for the summer of 2020 was to produce detailed evaluations of activities with a designed rubric. We had planned to include better design of activities with convergence to the main problem in-mind. We wanted to research the impacts of linear and non-linear activities from the literature and design a careful REU experience. In addition, a longitudinal study was going to summarize our findings from 2018-2020. Instead we continued with a virtual summer research experience with different observations.

We agree with other REUs that we were able to reach more students and also acknowledge if combined with other universities, we could be able to better interact with students. Working with already familiar students may have influenced our students' approaches to this REU experience. We also observed that we were able to show students more computational tools and scripts. We utilized previously collected data that have been waiting to be processed and analyzed.

Overall, the larger number of participants and increased diversity can be achieved through virtual REUs. However, the need for a hands-on component in which physical experiments are run, and data is collected and processed would need to be included, and to date, this was the least well-developed aspect of the virtual REU. As many researchers experienced online teaching after summer 2020, possibly better REU experiences can be developed.

4.0 References

Ashcroft, J., & Blatti, J. L., & Gonzalez, M., & Hacopian, M. T., & Cave, D. N. P., & Bojanini, I., & Bautista, E., & Jaramillo, V. I. (2020, June), *Early Career and Remote Undergraduate Research Experiences as Catalysts for More Impactful Community College STEM Opportunities* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2—34486.

Cadena, P., Nuwer, M., & Greengrove, C. L. (2020, December). Teaching Oceanography with Comics. In AGU Fall Meeting 2020. AGU.

Chin, S. M. (2020). An REU Experience Around the Globe. Matter, 3(5), 1387-1388.

Comert, G., & Pierce, C. E., & Berk, Z., & Huynh, N. N., & Petrulis, R., & Uddin, M. (2020, June), *Delivering Contextual Knowledge and Critical Skills of Disruptive Technologies through Problem-based Learning in a Research Experiences for Undergraduates Setting* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2—34377

Dalbotten, D., Watts, N., Geraghty Ward, E., & Berthelote, A. (2020). The REU on Sustainable Land and Water Resources 2020: a (Virtual) Tribal and Community-Based Participatory Research Experience.

Pierce, C. E., & Comert, G., & Darko, S., & Iyangar, B., & Petrulis, R., & Berk, Z., & Huynh, N. N. (2019, June), *Board 124: Infusing STEM Courses with Problem-based Learning About Transportation Disruptive Technologies* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. 10.18260/1-2--32219