Meeting Students Where They Are: A Virtual Computer Science Education Research (CSER) Experience for Undergraduates (REU)

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ABSTRACT

Currently, the computer science community is experiencing a rise in interest in computer science education research (CSER). However, current structures and belief systems within the discipline have largely relegated computer science education researchers to the margins. Computer science education researchers are mainly "lone-wolf" scholars in their departments that participate in CSER in addition to their more widely "accepted" computer science research. As such, there has been a resistance to offer doctoral programs in CSER. Florida International University has not only invested in CSER by hiring a CSER tenure-track faculty member, they have also established a School of Computer Science Education and Engineering Education. Despite this investment, one obstacle remains – the low visibility and understanding of computer science education research among undergraduate students. This makes establishing a research group of Ph.D. students challenging. In order to combat this obstacle, a four-year program was developed as a dedicated pipeline to the computer science education Ph.D. through a series of research experiences for undergraduates (REU). Summer 2020 consisted of the first cohort of this four year commitment. Given that 2020 was wrought with a series of unprecedented events, this REU was designed and executed virtually. This paper presents the plan, setting, execution, and subsequent evaluation of this virtual REU experience. Student-feedback was overwhelmingly positive; however, as with any endeavor there were many lessons learned.

CCS CONCEPTS

• **Social and professional topics → Computer science education**.

KEYWORDS

Computing education, Computer science education, Research experiences for undergraduates; Broadening participation

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1 INTRODUCTION - THE PROBLEM

According to the 2019 Taulbee survey, computer science Ph.D. enrollment is seeing an increase from prior years [38]. This includes an increase in women's representation, with women comprising 24.5% of CS Ph.D. enrollment. However, when disaggregated by race/ethnicity there has been a decrease in Ph.D. pursuit of those that do not self-identify as non-resident Aliens, Asian, or White. The decline takes the population from 7.0% down to 4.5%. In fact, the percentage of PhDs enrolled in computer science that self-identify as Black or Hispanic is a paltry 1.6% and 1.9%, respectively [38]. Disaggregated further by race and gender Black women make-up half of the Black PhDs enrolled and Latinas comprise 30% of Latinx students enrolled. In summary, the outlook for diversifying the Ph.D. in computing and, by proxy, future CS faculty for these groups does not look promising.

One strategy for drawing more students into Ph.D. programs has been research experiences for undergraduates (REUs) [27]. Many scholars have pointed to the effect mentorship has on engagement in STEM fields [28] and one such opportunity lies within the context of an REU. Undergraduate research or an REU is defined as the engagement of undergraduate students in research under the supervision or mentorship of a senior researcher [11]. In some cases, this senior researcher is a faculty member and in others they are graduate students, postdoctoral fellows, and/or more senior undergraduates with research experience. Prior studies suggests, that during these authentic opportunities to practice research, undergraduate students have oftentimes, demonstrated an increased interest in pursuing an advanced degree [30, 34]; increased understanding of subject material and its real-world application; better understanding of the needs and intricacies of the populations they were serving; (through their research); increased interest in careers in the field; gained an appreciation of the duties of a professional job in the field and assessed themselves as "better prepared" for workforce entry or to pursue graduate studies [35]; gains in research ability, leading to increased belief in one's own abilities, i.e., self-efficacy; development of student leadership skills and professional identity formation as scientist [31]. Prior work linking professional identity development to persistence and prolonged engagement, make this finding critical to potential graduate pursuit[32, 36].

In summary, REUs have an impact on undergraduate persistence and subsequent pursuit of graduate school. When further investigated to explore the benefits to those least represented in CS, e.g., Black, Hispanic, and first generation college students, the impacts are similar [24]. There was, however, the recommendation to emphasize or give explicit attention to the development of a strong sense of community and to take steps to ensure the recruitment of a diverse, inclusive cohort to aid in fostering a meaningful experience for diverse populations [24].

Drawing on this prior work, that underscored the importance of REU on graduate enrollment, [68, 80] the PI designed a four year REU for computer science students with specific recruitment strategies aimed at recruiting Black and Hispanic women. The REU was designed so that each year students would be recruited to Florida International University for two weeks to participate in intensive education research learning modules during the summer. The overall design included education research training that aligned with the proposed timeline of a large-scale exploration of the experiences of Black and Hispanic women in computing. With this in mind, year one was designed to establish a foundation of understanding around defining CSER - what is it?

Following the model set forth by iAAMCS, we developed a targeted recruitment plan (discussed below)[18]. The intent was to recruit eight students to participate in the program and have them reside on the FIU campus in dormitories together in order to establish a community of practice [73, 74]. Then, upon completion, they would return to their respective campuses, and participate in monthly virtual meetings in order to remain connected and receive mentorship (traditional and peer). During the lifetime of the 4-year project, these students would act as ambassadors for the project as well as take ownership of the research through data collection, analysis, survey instrument development, etc. according to their interests. These students would also be encouraged to participate in manuscript writing and conference presentations. The objective being to engage them in computer science education research and provide an opportunity to experience the rewards and satisfaction associated with this work.

The objective of the REU was to develop a deliberate pathway to the computer science education research doctorate by:

(1) providing a meaningful research experience in the domain of computer science education research
(2) building a community of computer science education research practitioners
(3) develop computer science education researchers for future data collection

However, the global pandemic - COVID-19, presented a new set of obstacles outside of the normal logistical challenges associated with hosting an REU. For example, creating a meaningful experience virtually. In this paper, we will provide the motivations behind the REU, mechanisms for recruitment, background on the facilitators, curriculum and content presented, and the format. It will then close with the highlights of the REU, student evaluations, and reflection on how this manner of delivery served us and may serve others with some recommendation on how to enhance the experience.

2 RELATED RESEARCH

When designing the REU, we turned to prior research to ensure that we used evidence based practices to fulfill our stated objectives (above). The most notable practice was the integration of mentorship. More specifically, mentorship of sameness (mentors with shared social identities), in order to foster identity development; in particular, identity development as a computer scientist, computer science researcher, and as someone that belonged in computing. Prior research suggests that mentoring relationships are often mutually beneficial for both the mentee and mentor [19]. Likewise, scholars have reported that same gender/same race mentoring relationships have notable improvements (among the mentors) in: communication skills, confidence and identity[33]. When exploring mentoring relationships of women (to women), one research study reported that such mentoring relationships helped women feel less isolated and experienced decreased fears of failure in male dominated fields[12]. These benefits of mentoring have also been expanded to identity development and salience [22]. Scholars have suggested that mentoring and identity are connected. Identity scholars that believe that identity is malleable and fluid also ascribe to the idea that identity is influenced by social and cultural factors, such as discourse and relationships - in this case mentoring relationships. It was this necessity to create a community through mentorship, that we shaped the REU experience.

3 RECRUITMENT/PARTICIPATION

The focus of the initiative was to recruit Black and Hispanic women. With that in mind, the recruitment was executed at the Grace Hopper Celebration (GHC). We sent four women (two undergraduate and two graduate students) affiliated with the research group to GHC in the fall of 2019 to engage with and actively recruit participants for the REU. The recruiters were given flyers and talking points to make sure we had a unified message around the intent and purpose of the REU. The flyer had a link to the application and yielded 42 women applicants. That list was narrowed down to 20. Twenty-two applicants were eliminated based on either being incomplete and/or because of an articulation of interest in research areas not aligned with the effort - understanding the pathways of Black and Hispanic women in computing. The twenty remaining applicants were reviewed by the research team and eleven were selected on the basis of pure interest in the topic. It should be noted that no GPA was requested or any transcript data. For this effort, we chose participants on the basis of passion over academic achievement. As GPA and transcript data can often depict an incomplete story of the accomplishment of students [37].

The eleven selected participants were then invited to join us for the summer 2020 cohort. Of which two declined on the basis of conflicts due to graduation and a study abroad opportunity. This brought our cohort down to nine. We then invited the students to bring a "plus one." Being mindful of the iAAMCS mentoring guidelines we wanted to invite our participants to identify a woman from their school to bring with them. This served two purposes, 1) it gave them a friend at the REU; and 2) provided a support system when they returned to their respective campuses. It is worth mentioning that this "plus one" idea was presented when we thought we were still hosting the REU in-person (pre-COVID). The "plus

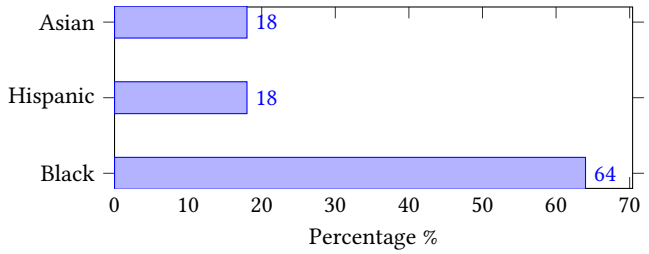

Figure 1: Race/Ethnicity of the 2020 REU Participants

one" yielded an additional four participants, bringing our total to thirteen. However, the transition to a virtual setting resulted in the loss of two more participants. Bringing our final participation to eleven (participant demographics see Figure 1). Of the eleven participants, ten attended every single day.

4 FACILITATORS

The facilitator team consisted of current undergraduate and graduate students and the faculty advisor from the Listening and Engaging with Alternative Research Narratives in Computer Science (LEARN-CS) research group. The team consisted of five Ph.D. students, one Master's student, and three undergraduate students that have participated in computer science education research for at least one semester. Of the Ph.D. students three had successfully completed their qualifying exams and two were first year Ph.D students. It is also worth noting that eight out of the nine facilitators and the PI self-identity as female.

The facilitators helped with the content development and delivery. As a group, we identified objectives for the two-week engagement that we determined were foundational topics for any new comer to CSER (discussed below). Each team member self-selected an area of expertise and leveraged the principles of a flipped-classroom and active learning for the pedagogical approach. Meaning they identified YouTube videos or readings that corresponded with the topic for the students to engage with or read prior to the topic being covered. Then during the topic timeslot, students were encouraged to participate in Menti surveys or discussions led by questions/prompts developed by the facilitator related to the content area. Given the virtual manner of REU, the facilitators used menti.com as ice-breakers and used the Zoom BreakOut room feature for smaller discussions and think-pair-share activities.

5 CONTENT

Content was selected by the team of facilitators. We started with a brainstorming session of all of the topics we thought were critical to our development as CSER practitioners. We then prioritized the list according to their alignment of the goal of Year 1 of the REU experience - to develop effective interviewers for data collection. We decided that context mattered and thus we identified the content areas, described in Table 1

The objectives for year one for this project were to 1) introduce the REUs to computer science education research as a rigorous subdiscipline of computer science; and 2) teach them how to conduct qualitative interviews. The intent was to send them back to their home institutions prepared to help collect data for the larger inquiry (into the pathways of Black and Hispanic women to and through computer science). Given these objectives we thought it was critical that they be presented with opportunities to learn about the various research paradigms, as well as be given the space to reflect on their own position within these varying paradigms. We started with developing a baseline understanding around the value and impact of research [20]. We followed that up with context for the work they were supporting by presenting the current representation patterns in computing and used that as a segue into computer science education research more broadly [1, 2, 6, 8].

1. Value of Research	6. History of CSER	11. Qualitative vs. Quantitative
2. Underrepresentation in CS	7. Educational Philosophy	12. Methods
3. Research Impact	8. Research Philosophy	13. Interviewing
4. Why CS Ed?	9. Literature Reviews	14. Representation matters
5. Switch Struggle	10. Meaningful (Research) Questions	

Table 1: Content Areas

After presenting a survey of CSER work to demonstrate the breadth of the field, we worked on helping them to understand the origins better by giving them two lessons centered on educational philosophy and research paradigms. We felt as if understanding research paradigms often influence our epistemological beliefs and thus influence our methodological choices [13]. As such, creating opportunities for our REUs to be reflective about their own beliefs could help them understand themselves as researchers better.

We followed the philosophy up with the fundamentals of research related to the importance of literature reviews [7, 10] to developing robust research ideas and questions [3, 4]. We gave a brief overview of methods [5], primarily qualitative and quantitative in order to transition into methods. In alignment with the objective of training data collectors it was critical that they understand the background behind the method of interviewing [9] and were given opportunities to practice the skill before the REU was complete. As such we had each participant complete their CITI responsible research training and had them interview each other, then participate in a reflective activity around the joys and challenges of interviewing.

6 VIRTUAL DELIVERY

We developed a Google drive for the material, which consisted of a detailed outline of the topics to be covered. Each topic area had videos, podcasts, and readings (cited in the above sections) that situated the work, so that students would have a foundation from which to start a conversation centered on the topics of discussion.

The need to present the material virtually presented unique challenges related to computer fatigue, engagement, and participation. Given that one of the objectives was to create a community, we had to be deliberate in our development and delivery of material to ensure that we established an inclusive virtual environment. An environment that was mindful of the obstacles our students might be facing during COVID. This includes but is not limited to adequate internet access, familial obligations, etc. With these concerns

in mind we collected and reviewed literature related to productive virtual meetings.

The literature related to this topic highlighted things like: encouraging participants to enable their video, sending an agenda ahead of time, connecting people, calling on people to participate (to minimize multitasking), capture real-time feedback, virtual water cooler, visual focus, and breaks (lots of breaks) [14, 16, 17, 21, 29]. As a team, we tried to balance these best practices with the needs of our participants. For example, we did encourage participants to enable their video but also noted that if video was not an option due to bandwidth challenges, they could simply turn their camera off. Oftentimes, participants turned their camera off during the full-group engagement but turned their cameras on when in breakout rooms (or smaller intimate settings). We created the agenda a week ahead and published it for the participants. We created a Discord for the students to begin to connect, a week before. We had daily chat prompts to get them talking to us and each other. In Discord, we also had a poll mechanism for anonymous real-time feedback. As stated before, we leveraged active learning engagement strategies - think-pair-share [25], mentimeter questions [23, 26], and discussion prompts[15]. The schedule included breaks every 20 minutes; alternating between 5 minute breaks and 15 minute virtual water cooler breaks. Virtual water cooler breaks consisted of breakout rooms where participants could either stay and chat with those in their breakout room, walk away to tend to other business, or a mix of both. Most times they opted to engage with each other. We shuffled the breakout rooms everyday so they could get to know more of their cohort.

7 RESULTS/EVALUATION REPORT/STUDENT FEEDBACK

Upon completion of the REU, students participated in an online survey that captured their self-assessment of their research skill development, sense of community, identity development, and interest. The survey was completed by n= 10. Based on our findings, participants benefited most by learning about the foundations of research, hearing from the graduate students in the LEARN-CS lab, and gaining more exposure to computer science education research.

7.1 Gaining research experience

Reflecting back on the objectives, the first objective was to provide a meaningful research experience. All participants agreed or strongly agreed that the research experience improved their computer science education research skills with 90% reporting that methods training was the most helpful in learning new research skills (see Figure 2). On the topic of data collection skills 90% agreed or strongly agreed that they improved compared to only 50% seeing an improvement in their data analysis capabilities (see Figure 2). Similarly, participants agreed or strongly agreed that they improved their oral communication skills compared to only 50% seeing an improvement in their written communication. When asked about their professional skills or abilities 90% agreed or strongly agreed that participating in the research experience increased their confidence in these areas (see Figure 3). And, despite the limitations of conducting the REU virtually rather than in-person, 80% reported improved collaboration skills.

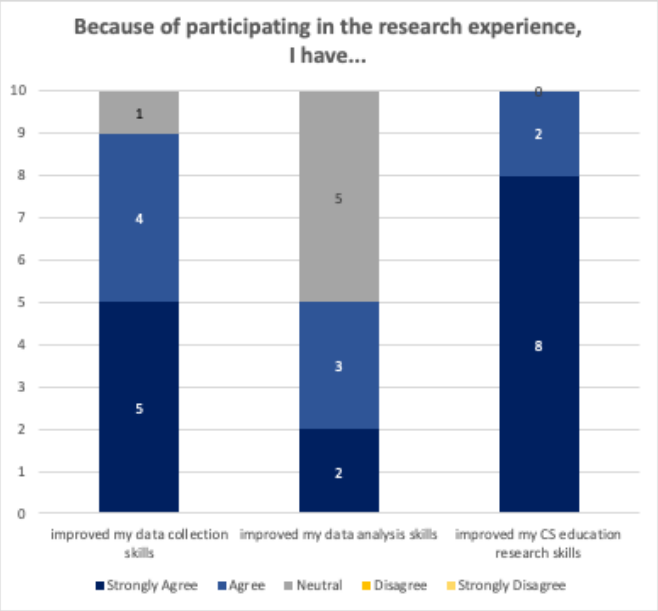

Figure 2: Research Skills Self-Assessment

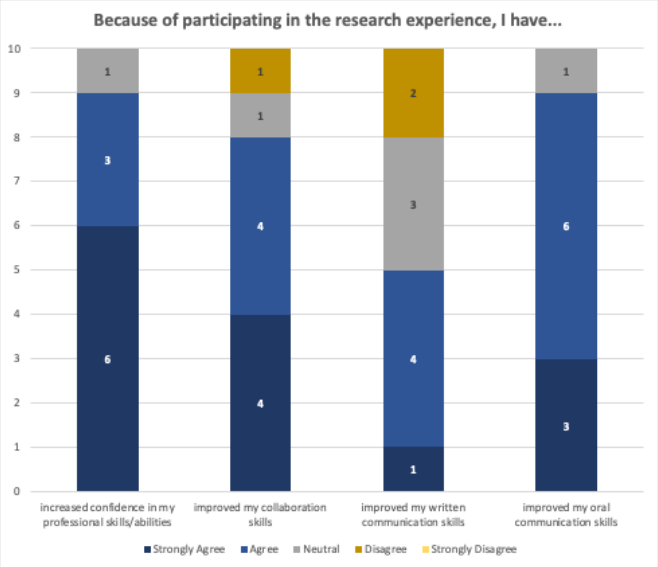

Figure 3: Soft Skills Self-Assessment

As seen in Figure 2, the majority of participants reported that they strongly agree the experience improved their CS education research skills.

7.2 Establishing a sense of community

The second objective of this initiative was to establish a sense of community that would extend beyond the confines of our two weeks together. The evaluation survey suggests that we were able to at least establish a foundation from which to build a community.

One participant stated that, "The other REU participants are great. Connecting with other women across the country that have similar interests and different backgrounds was really empowering and I'm happy to have built some relationships with them."

As we had hoped, the community included the LEARN-CS facilitators as well, with one participant describing her interaction with the facilitators as, "Dr. Ross' graduate students were extremely helpful. Learning about their journey towards pursuing a PhD was insightful and help[ed] guide my decision on whether I want to pursue a PhD myself."

Likewise, the REUs legitimate participation in this learning community helped develop and, in some cases, strengthen their identity salience with all participants demonstrating having gained a new identity as part of the computer science education community. Students noted that they had benefited from the mentorship of Dr. Ross, her graduate students, as well as the other participants who shared identities and interests within the field. When asked about their sense of belonging to a community, 100% of participants agreed or strongly agreed that they had new colleagues they can call upon for support.

7.3 Fostering an interest in computer science education

In alignment with the final objective, we inquired about participants' interest in continuing their work in computer science education research. We started by asking about the most influential element of the REU that increased their interest in CSER and 90% of participants reported that hearing about the research of others increased their interest in computer science education research. The vast majority (90%) agreed or strongly agreed that they were more interested in going to graduate school for computer science education research because of their participation in the research experience. While 80% reported an increased interest in doing research (broadly) at their home institution; however, only 50% reported an increased interest in conducting computer science education research at their home institution. Furthermore, 90% reported that their interest in working in a job where they could do computer science education research increased because of their participation in the REU.

8 LESSONS LEARNED

Through our analysis, we have identified several potential areas of improvement for the REU. To provide a more meaningful research experience within the domain, intend to create more opportunities for improving written communication and data analysis skills. Feedback on community building was perhaps the most positive, with participants highlighting the benefits of connecting with graduate students working in the LEARN-CS lab. We will continue to build on opportunities for connection and visibility among graduate students with shared identities. We had a panel on the final day of the REU called "Representation Matters" where we invited two Black women PhDs and one Hispanic woman PhD (in STEM) to share their journey with our REUs and it was very well received. Some citing it has being the highlight of the experience. We may consider moving this up in the agenda or to bookend the experience to ensure they see themselves on the graduate pathway. One additional note for improvement was more face-time with the research group leader or PI. While the PI welcomed the REUs every morning, there were suggetions for her to be more engaged throughout the REU. While emphasis on peer leadership was intential based on literature, the REUs wanted more engagement with the PI. Finally, we saw that participating in the REU increased participants' interest in conducting research; however, the ability to pursue computer science education research at their home institutions was less clear. We intend to integrate additional training on how to pursue research or scholarship opportunities for pursuing graduate studies at other institutions to continue the advancement of minoritized groups within this field.

Most of participants (80%) were very interested in returning next year to conduct more computer science education research with Dr. Ross. That being said, students expressed some potential barriers to future engagement worth taking into consideration. They shared that financial feasibility, competing commitments, and the potential challenges with future travel made it difficult to know for sure if they could participate in the future. Based on this feedback, we also recommend providing a virtual option to, in part, address these challenges moving forward.

9 CONCLUSION

Coordinating an REU certainly has its challenges. Add to that the complexity associated with hosting an entirely remote experience and you have an adventure. However, the increased reliance on technology by us all has provided an opportunity to bring more experiences to a broader audience. The prior literature is clear, that REUs have impact on student performance and more importantly aspirational goals and future selves development. The impact is even more for those least represented in STEM graduate programs. The transition to remote, while challenging, gave these ten women a look into their potential future and most were pleased with what they saw.

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