FLAMES: A Socially Relevant Computing Summer Internship for High School Students

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***Abstract*—In this article, we examine a female-oriented, high school computing outreach program, FLAMES, consisting of an 8-week high school summer intern program run within a university computer science (CS) department. We focus on examining the effects of the program on students skills and affect towards computing. Much of the literature in CS outreach research examines summer camps, after-school programs, and other school-year events that often have a focus on only teaching students computing content. Our program is unique and socially relevant as students are trained to assist teachers with the development of Computational Thinking-Infused curricula for their classrooms. This paper presents the design of our program, an overview of the curriculum, and results including both student and teacher feedback. Results show that the program has benefited each of the parties involved, including its student participants, facilitators, and the teachers assisted by the participants. We share our lessons learned in order to help other CS departments develop similar broadening participation in computing programs.**

Keywords*—*Professional Development; STEM+C; Computational Thinking

I. Introduction

According to the National Center for Education Statistics, women received only 19.1% of all Computer Science Bachelor's degrees in the 2016-17 academic year [1]. Studies have indicated that women's sense of belonging has an important impact on their persistence in CS [2], and that having female role models and positive interactions with CS outside of the classroom are important strategies for promoting female participation in the discipline [3], [4].

The Future Leaders in Algorithms, Mathematics, and Engineering Sciences (FLAMES) program is a free high school outreach initiative hosted by our university focused on increasing diversity in computer science by broadening participation in computing to female high school students. Participants are not required to have prior programming experience. In 2019, the program was expanded to include an 8-week summer internship program serving 19 high school students, which ran through a research lab at the university.

This paper will provide a brief background and inform readers about the FLAMES internship. We will end by providing lessons learned for others looking to create a similar program for fostering female interest in computing.

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II. Background

A 2011 study illuminated promising practices for promoting gender equity in undergraduate research experiences, identifying several effective strategies for supporting women and encouraging them to continue in computer science and engineering [5]. The strategies included having a critical mass of female participants, providing role models and mentors, and discussing topics that relate to both men and women such as implicit bias as a way to indirectly introduce gender equity. Research also shows that women often place great value on social activism, which is a significant factor in the CS gender gap [6].

The use of socially relevant computing activities [7], experiences that make an impact in their communities and their world, can promote sustained engagement in CS and in STEM in general [4], [8]. Burge et al. report success in implementing a one-week residential summer camp for 25 high school girls focused around the design of a mobile application to be used by researchers to study animal behavior. The camp even included a trip to a local zoo for inspiration and understanding of the real world context for their mobile app. After participation in the camp, the participants were more confident in their computer science abilities and reported a better understanding of uses for computer science and what computer scientists do [9].

Similarly utilizing computing for social good, the Game2Learn model [10] was designed to leverage educational game development for retaining students in CS by having undergraduate students develop games to teach CS concepts using rapid prototyping. This project model leverages students' enthusiasm for games and social relevance as the finished products can be used to teach computer science.

Community-based service-learning is an educational approach which situates learning in a community service setting. We leverage this framework by having our students help local state teachers create projects for use in their classrooms, allowing our students to use their technical skills to benefit education in their communities; as women are more likely to chose activities that help people, showing our students that CS can be used to help people is important for broadening participation in computing [11].

We have implemented several of the aforementioned strategies in FLAMES. We made a focused effort to intentionally recruit female students. Participants were provided role models and mentors through university student facilitators, faculty interactions, and research lab rotations shadowing undergraduate research interns. We additionally followed recommendations to host conversations around implicit biases and ethics in computing as well as to create a community of students and role models which encourages young women to remain in CS. Additionally, our students develop rapid prototypes of computational thinking (CT)-infused projects that will be used by active K-12 teachers.

III. Context

A. Participant & Facilitator Data

We recruited primarily through high schools within the county and a few rural schools in nearby counties. Marketing was targeted to young women, however any student could apply. Students were allowed to share recruiting information with their friends and neighbors. As this program is designed with equity in mind, in addition to student essays, reviewers also looked at available role models and parental education. Though not required, all selected participants had taken at least one programming course in school. A breakdown of student demographic information is found in Table I.

TABLE I
FLAMES Participant Demographic Information

Total	Gender		2018-2019 Grade Level				Black or
	Female	Male	9th	10th	11th	12th	Hispanic
N=19	68%	32%	10%	21%	69%	0%	5%

There were two female facilitators who lead the summer internship (1: Hispanic PhD recipient, 2: White PhD student).

B. Implementation

The internship program served two main purposes: first to provide assistance to teachers in an Infusing Computing professional development (PD) and second to show prospective students what socially relevant computer science and research looks like. The internship ran from 9:00 AM - 4:00 PM each day with a 1 hour lunch break at noon. Depending on students needs, they could work morning, afternoon or both. In order to prepare interns for supporting the PD, we offered a 3-day leadership workshop and a 1-week coding course that covered each of the block-based programming activities taught during the PD. Both week 3 and week 8 of the internship coincided with an Infusing Computing PD [12]. For this PD, students provided coding support for K-12 teachers who were designing CT-infused projects for their subject area classrooms. The interns typically worked in pairs to help complete teacher projects or resolve issues. Students communicated with teachers through video calls, group messaging, and in-person.

The other four weeks of the internship focused on developing and enriching students' computing skills through web development and rotations through CS research labs. Students spent one week developing and updating websites for organizations on campus and two weeks embedding themselves within active research labs, shadowing student researchers. Each intern was able to choose two labs that they wanted to participate in for 5 days; their themes were: biological algorithms, critical infrastructures, health analytics, collaborative computing, intelligent tutoring systems, and educational games. Within these labs, some students helped with field study observations, software testing, conducted literature reviews, or classified data. Throughout the internship, graduate students would do impromptu visits to the interns to get help with research ideas, data wrangling, and pilot testing summer camp activities; they also spoke about ethics, implicit bias, and bias in machine learning.

Ending the internship, students presented their experiences, including what they had learned in their research rotations. Presentations were attended by the department faculty, graduate students, and undergraduate researchers as well as community members from the interns' schools. Students also attended the university research symposium, viewing the outcomes of the undergraduate researchers they previously shadowed.

IV. Evaluation & Feedback

We reflected on this experience, for future improvements, by examining student artifacts, interview data, and communications between interns and those they helped.

A. Student Perspective

Student perspective data comes from their final presentations, semi-structured interviews with 10 students (9 female, 1 male), and 3 students' weekly blogs written for school credit (2 female authors, 1 male).

On Skills Gained In addition to the eleven students who received school credit for the hours worked during the internship and the seven students who requested letters of recommendation for their college applications, each student walked away with skills and experiences that they could add to their resume and use in the future. Students gained professional skills such as client communication, time management, and collaboration. They also learned technical skills and gained experience working with programming languages and software tools like, Snap*!*, Python, Java, Julia, R, Unity3D, PyChart, Eclipse and git. After learning some data analytics in a research rotation, one female student shared, "I just found birth data online in my free time and was able to visualize the data to see that there was a drop in birth on weekends versus weekdays." Another student reflected in their blog, "This internship definitely helped me build and develop my skills in computer science as well as working with other people. I got to practice working in a professional environment, which was a relatively new experience for me."

On the Working Environment To foster a positive working environment, we were lenient in attendance and schedules. Interns had individualized schedules allowing them to attend external commitments. We took this into consideration when pairing students so that they could enjoy and meaningfully

contribute to the internship. We believe that we were successful on this front. One student shared in their blog that "The work atmosphere here is very chill... and the rules are not too strict. Decisions are made cooperatively, as the researchers are always talking with each other about [research decisions], and frequently consult us if we have tested what they are talking about. Everyone works very hard though, and you can tell they are passionate about what they are working on. I really enjoy the work environment, as I feel very comfortable here and I feel like I can share my voice." By implementing a more relaxed work environment, we were also able to provide opportunities for students to learn teamwork and collaboration while having fun. During work lulls we often allowed students to play games requiring the use of decomposition, abstraction, and other skills beneficial to CS careers. Additionally, these informal activities helped to build rapport among students, leading to the creation of community in computing, vital to women's persistence in CS.

On an Expanded Understanding of CS One of the biggest takeaways students shared from participation in the internship was an expanded understanding of the ways in which computer science can be applied. One student remarked, "I thought computer science was just programming, but coming here I got to see how computer science can be applied to multiple different fields." Many students had taken at least one computing class and thought of computing as merely making different forms of technology, apps, programs or tools. The internship experience helped to fight the misconceptions that students held about computer science. As students put it, "[FLAMES] kind of crushed that stereotype that all you're doing is staring at a computer screen all day," "It's not just somebody who's sitting and constantly typing out code," and "There are so many things you can do with computer science that doesn't mean you're just in a room with a laptop. You're working with people from the national parks. You're catching genetic abnormalities." By realizing that computer science was more than a cubicle, they also learned about the role collaboration plays in the field. One student said, "Computer science, although you can do things on your own, it's a team effort and that's something I didn't think about before."

On Research Rotations Many students chose the research rotations as their favorite part of the internship as it enlightened them on the forms and domain applications that CS might take. This includes "learning about a project that has real world application." and "I'm no longer afraid to read research papers. I understand how abstracts and research papers work." The research rotations allowed students to interact with and learn from researchers with a variety of backgrounds. One student shared, "I had a limited view of CS, this really helped open up my perspective; [Undergrad1] is a business major and isn't limited by her major about being able to use Python and CS." These interactions with college students allowed the high school interns to ask questions and learn more about the college experience. On the value of conversations one student said, "[Undergrad2 and I] talked about college a lot. What college and computer science has been like for her. What's been good, what's been not good. I think especially creating those bonds with the undergraduates was helpful." "She also shared about her application process. I think just having insight into that was very helpful." We also heard changes in students' attitudes: "I learned a lot more about college and I think I feel better after talking with [the facilitators] that it's manageable if you try." [Student] further stated "Before I did this program I used to think [CS] would be extremely challenging. It is challenging, but it's doable if you have the interest." Another student went on to say, "Not until this internship had I really understood how [CS] looks in the real world and how you can apply it in different careers" and explained that this knowledge helped them to consider a career that uses CS.

On Helping Teachers Several students mentioned that working with teachers prompted them to apply for the internship. In an interview, one student stated, "It was cool knowing we made an impact for their classrooms because they can use the programs we made to teach people." In addition to the excitement of making helpful projects, students also spoke positively on their teacher interactions, "[the teachers] were all so excited to code and their passion was contagious... all their curiosity about computer science was refreshing to see". When asked about how it felt to help teachers, one student spoke about the experience of explaining the projects and programming concepts, saying "You have to be more detailed but also concise and simple so they know what you are talking about." Another student explained, "I'm really proud of the work that we've gotten done...It seems like we're really helping the teachers out a lot and they're very thankful. It still feels weird to be teaching teachers, but it's so nice when we finish and they praise us. It was also fun to see how the teachers acted as students." Likely as a result of these interactions, without prompting, students mentioned in both interviews and presentations that they saw "the importance of computing in education." One student stated, "I would have never even thought that an English teacher would use a [coding] project for their class, but they did and it was pretty cool," continuing "I really do believe that CS should be in every school for the future."

Overall, the internship proved valuable to students. They learned professional and technical skills, enjoyed helping others, increased their interest in computing, and gained a broader understanding of CS and the college experience. One student said, "[This experience] has shown me that computer science is used on a daily basis and has restored my interest in programming and developed my people skills."

B. Teacher Perspective

Forty-one off-site teachers requested the interns' help and all 10 local teachers were paired with an intern developer. In total, the interns helped create 45 projects for 43 teams. Interns made small code changes or created entire projects depending on the teacher's level of coding comfort.

In reviewing teacher reflection surveys and the #code-help chat channel used during PD, teachers showed avid appreciation, thanking students frequently for all their help. Teachers

found the interns approachable and appreciated receiving individualized help. "The Zoom Kids are great!! Really helpful as I was creating my project. So willing to answer my questions and offer suggestions." One teacher noted "I think the feedback and implementation was shocking. Whatever was requested was done. I have never experienced anything like that before." One teacher shared "...I think my brain was just so tired, I could not think of a way to start! Once she got rolling, I could see where I wanted the programming to go." Overall the teachers were very receptive to the interns, "I enjoyed the opportunity to work with the HS students on our projects. They were incredibly knowledgeable and I would not have come up with the project that I did without them!! That collaboration piece was really unique and I appreciated the help!"

C. Researchers Perspective

A total of 6 professors participated in the research lab rotations. They were already hosting REU students and "were not opposed to the idea" of having an extra intern or two shadow their students. After having interns the researchers stated, "The interns were eager to work on whatever tasks we gave them, they did a good first pass at tagging data." Another mentioned, "I was conducting a classroom study and the interns were very helpful in collecting observations. I wouldn't have been able to collect that extra data on my own." One professor noted, "it would have been good to know their exact programming proficiency ahead of time. My first two knew JavaScript and Python, the second set of students had weaker programming skills and so my students had to come up with other tasks for them." Overall though, the professors and researchers agreed that they would want to host students again the following year.

V. Discussion & Lessons Learned

After reviewing all of the feedback, we believe the FLAMES internship was successful in encouraging students, especially young women to pursue further interests in computing. Students were given the opportunity to learn computing skills from college role models and mentors, to have casual conversations with researchers about computing careers, and were able to see their projects have an immediate impact on the community. We now share our lessons learned from implementing and evaluating FLAMES for others who may wish to replicate our program.

[1] When running a large K-12 computing PD with limited staff, knowledgeable HS students make great substitutes.

[2] Assisting teachers provided a good opportunity for students to work on community-focused projects that have a social impact, which plays a large part in recruiting female students.

[3] Working on projects for members of the community allows students to reach beyond their technical comfort zone to attempt problems new to them.

[4] You can run a female friendly program that includes males.

[5] Provide training and information up front to groups hosting students. Knowing interns prior experience and coding skills can help groups prepare activities for their arrival.

[6] Small details can leave a large impression on students. Providing certificates or professional presentation locations make ordinary student experiences feel special.

Additionally, to help feasibility for others, we believe that a shorter, event focused internship could be adapted from this model, including activities like research rotations, facilitating K-8 coding camps, and industry visits and tech talks.

VI. Conclusions & Future Work

Overall, participation in FLAMES proved valuable to students. They learned professional and technical skills, enjoyed helping others, and gained a broader understanding of computer science and the college experience. Furthermore, the interns were valuable to young researchers who were able to get assistance on their summer projects. Though the research rotation experience was far from flawless, it had a strong impact on the students and was the favorite experience of the internship for many students. The interns were also mission critical for the success of the PD, appreciated by both PD facilitators and teacher participants, who enjoyed the students' individualized support on their projects.

In the future, we would like to balance the research focused CS activities with more industry and professional oriented computing careers. We believe this could be achieved through sponsored site visits or invited presentations from industry employees. We intend to continue the FLAMES program refining our activities as we go.

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