Computer Science is about Problem Solving: Highlights from a 6th Grade Computing Camp

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***Abstract*—Dr. Bushra Anjum and Mr. Greg Wilcox organized a computing camp for 6th graders at the Los Osos Middle School in California during the summer of 2019. Though the school has a computer lab, it lacks a computing curriculum along with CS-trained faculty. Dr. Anjum led the camp--- consisting of 5 highly interactive training sessions--- to introduce various exciting computing concepts to the students. The sessions were conducted with the help of the school's STEAM (science, technology, engineering, arts, mathematics) faculty and included videos, active discussion, and hands-on activities introducing new skills. This effort was aimed to inspire young people to step up and contribute to the future of technology.**

In this paper, the authors share some of the lessons and insights gained from this experience. They also discuss those strategies that worked and those that didn't while sharing some recommendations for students and faculty interested in conducting such outreach.

Keywords— K-12 education, equity, problem solving

I. Introduction

Data driven decisions in education at the site level include thinking outside the box. One such approach featured in this experience paper identifies the process and outcomes of a computing camp, a pilot program to encourage and engage 6th grade students in the study of computer science.

Gender inequity in the computer science field has been a well-known issue in the tech world. The number of women enrolled in computer science at secondary schools, universities, and employed in the workplace reflects a disparity in our current population. According to the United States Bureau of Labor Statistics, in 2018, computer occupations employing women ranged from 37.5 % for computer systems analysts to 10.3 percent for computer network architects[1]. Clearly, the United States Census Bureau 2018 numbers do not mirror the female population, 50.8 %[2].

Organizations and programs have historically sought to level the playing field for women in computer science. Girls Who Code, since 2012 have continued to build the numbers of women working in the computer science area. In 1995, 37% of computer scientists were women. Today, it's only 24%. If we do nothing, in 10 years, the number of women in computing will decrease to just 22% [3] [4].

The focus of this computing camp was to increase female interest in underrepresented computer science fields.

Equity specifically in underserved minorities and women employed in technology fields by companies, big and small, are posited as the rationale for the computing camp collaboration with Mr. Wilcox and Dr. Anjum. The journey to a computing camp section of a 6th grade STEAM course being co-taught by an expert in the field of computer science, Dr. Bushra Anjum, a data analytics program manager, currently with Doximity begins with a visit to Amazon in San Luis Obispo, California.

II. Computing Camp at Los Osos Middle School

Los Osos Middle School is located on the Central Coast of California, about halfway between Los Angeles and San Francisco. The 6-8 middle school, had 599 students in the 2017-2018 school year, (published 2018-19) per the most recent California Department of Education, School Accountability Report Card. 61.1 percent of the student population is White (not Hispanic), and 49.74 percent are considered socioeconomically disadvantaged. There were 184 6th graders in attendance during the 2017-18 school year [5]. However, according to the Los Osos Middle School registrar, Anne-Marie Hoffman, in 2018-19, there were 555 students, 297 males (53.51 %) and 258 females (46.49 %). The STEAM class when the computing camp session was introduced had a total of 32 students, 20 males, and 12 females. The course enrollees were scheduled based on a rotational wheel that included 4 other STEAM classes; robotics, video production, aerodynamics, and transportation.

The school has a 1:1 ratio of computers to students, yet computer science is not a formal part of the course choices. The majority of computers are Chromebooks with 2 labs of desktops. A degree of computer programming is embedded in the 6th grade when all 6th graders learn to use Scratch. Last year one class of 8th grade students learned how to create interactive 3D images using Unity and GIMP. Some 8th grade history students created augmented reality presentations triggered by QR codes on a student-created poster. In 2018, Los Osos Middle School received a national honor being designated as a "Schools to watch," one 22 middle schools in the state of California [6].

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A. *The Industry-School Partnersihp*

Initially, Mr. Wilcox brought 27 students from Los Osos Middle School to visit a variety of local businesses as part of career exploration, including Amazon. Dr. Anjum reached out to Mr. Wilcox, offering to teach a unit on computer science. Later in the school year, Wilcox contacted Dr. Anjum, who had moved up to a start-up, Doximity, headquartered in San Francisco. She telecommuted from San Luis Obispo County and still wanted to teach 6th grade students about computer science. Our initial meeting at Los Osos Middle School included 3 other STEAM teachers.

The partnership between an industry expert and the local teaching staff has been critical to the success of the camp. It is essential to recognize that while the industry expert may know their technical craft, it is the teachers that know their students. The teachers have been working with these students for months, in some cases years, and can advise best on the complexity of the content, delivery and presentation style, and identifying and following up with the most and least interested students.

B. *Lesson Plans and Execution*

Dr. Anjum decided to make the camp not focused on programming, but "problem solving". The primary goal was to introduce the field of computer science to the students and the immense potential for good it holds. The secondary goal was to inform that programming is just a small part of computer science. The bulk of the work that computer scientists do is figuring out the right solution, which requires creativity, critical thinking and collaboration.

The first session was focused on what computer science is, a brief history of how it came about, and the applicability of computer science in every field today, ranging from medical to entertainment to agriculture to historic restoration, etc. We were able to convert the then recent tragedy of the fire related destruction of Notre Dame de Paris cathedral into a teaching moment. We highlighted the work of late art historian and computer enthusiast Andrew Tallon, who meticulously mapped Notre Dame in three-dimensions using laser scanners. Using his digital maps, the reconstruction of Notre Dame will be possible with an accuracy of 5 millimeters [7]. Students responded to this story with awe and delight as they saw how "loosing a historic site by a disaster" was a problem and computing provided a solution. The students also responded well to the computing research and innovation in robotics that provide assistance for the disabled, and veterans who have lost limbs in the line of duty.

The second session was focused on the internet and how an army project started in the era of the cold war ended up as the biggest communication revolution in the history of mankind. The students enjoyed the story immensely, on how the army's intention to create a "resilient **inter**connected **net**work" became the "**internet**". Many boosted that they are going to tell their parents and friends that "internet" is not really a word, or at least it wasn't a few decades ago.

Another session was focused on security, where various aspects of wired and wireless networks were discussed. The notion that "it is easy to bury a wire or lock it in a building, but it is impossible to control the air" led to interesting follow-up discussions. This led to discussing the Frequency Hopping Spread Spectrum work as a means to secure radio communication. We also discussed securing the message via encryption, and the students were introduced to Caesar Cipher. We did a few exercises in the class where students were given encrypted messages and a key and were asked to decrypt the message. It was one of our highly engaging exercises. We also recognized the potential and converted it into a mid-session feedback opportunity. More details on it are shared in the next section.

Finally, we had a session dedicated to the Binary encoding. We sparked the students' interest by asking, "Why do we count in 10s? Why not 6 or 12?". It led to a fun discussion where students finally narrowed down and tied decimal to 10 fingers. We segued into computers at this point and asked, "But poor computer have no fingers to count on. What does it have?". We got various answers, circuits, wires, electrons, electricity, power! And from there, making the connection from electricity to the binary state was straight forward. In that session, students also learned to convert decimal numbers to binary using repeated divisions and were successfully able to convert 6 digit decimal numbers. This actually came as a surprise to the instructor as she was expecting the students to convert 3 and 4 digit numbers easily and struggle with 6 digits. The class, however, aced it. A student later shared he is not a big fan of math, but he enjoyed doing this exercise as *"collecting 0s and 1s is fun and funny"*.

C. *Creative Mid-Session Feedback*

Students were thoroughly engaged in converting encrypted messages, given to them by the teachers, to unencrypted ones using Caesar Cipher. We recognized the potential here and turned it into a mid-session feedback opportunity. We asked the students to write an encrypted message to Dr. Anjum and give her the decryption key. She will decrypt it later. The message could be anything related to the computing camp, what are they learning, what are they liking or not linking. Students were given the option of not writing their names on the paper so that they may express themselves freely.

Though we were skeptical about the messages we may receive, the overall feedback was increasingly positive and encouraging. We are sharing a few of the notes below.

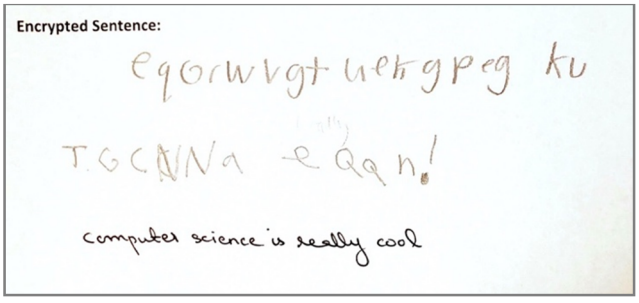

Fig. 1. Encryption based feedback 1

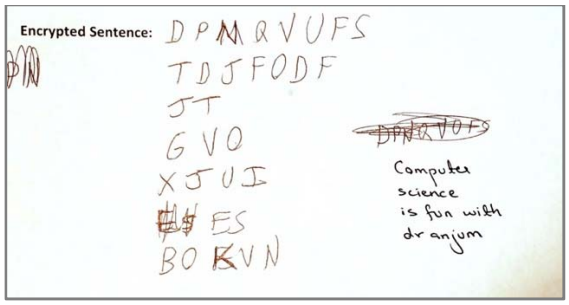

Fig. 2. Encryption based feedback 2

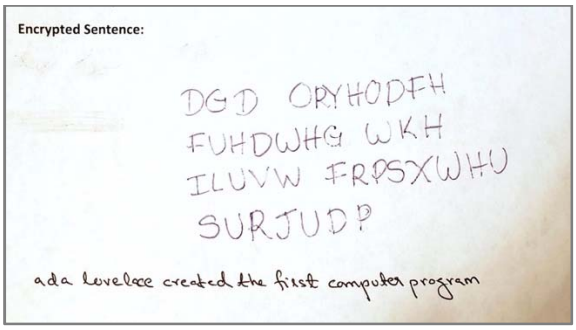

Fig. 3. Encryption based feedback 3

III. Reflections and Recommendations

One lesson we learned early on is that while numbers, such as pay or open job postings, may be of primary importance to teens and adults, they matter little to the students of this age group (ages 10 to 12). We started the camp by sharing the statistic" By 2026, there will be an estimated 3.5 million jobs related to computing open in the U.S." and "The average salary of a software engineer is $120,000". These statements were met with neither understanding nor appreciation by the students.

We quickly revised our strategy and started focusing on the impact computer scientists make. They have the potential to do what heroes do, act in service of others who are in need, whether for an individual, a group, or a community. The idea of heroism struck a chord with the student audience.

Our end of session student evaluations showed that the students responded in a positive way to the lessons leading to solving problems similar to those of computer scientists. One question asked of all students was: "How did it feel about learning about some of the problems real computer scientists face today?" The following are a few of the characteristic responses: *"It was fun to learn about it from a woman's point of view. I like the secret code where they used it in the army." "I felt reassured because although they [computer scientists] run into problems, they find a way to fix them." "I remember Dr. Anjum teaching us how to code and decode."*

Below we share some of the handwritten notes received as the end of session feedback.

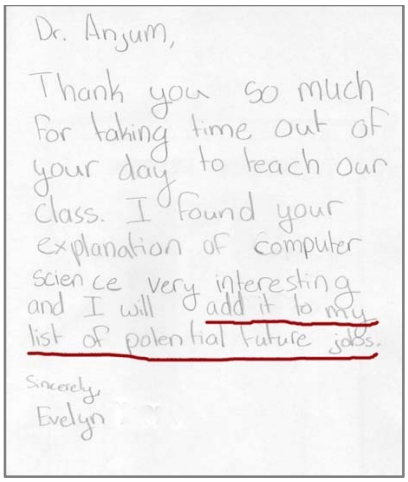

Fig. 4. End of session feedback 1

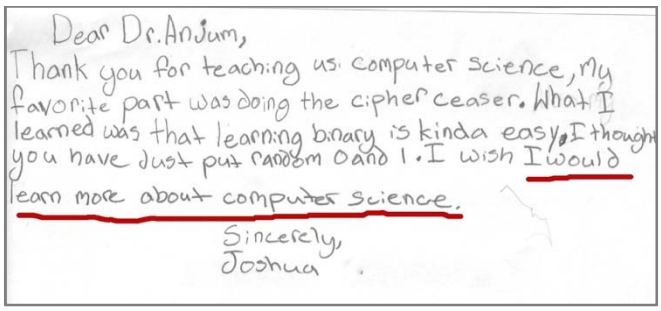

Fig. 5. End of session feedback 2

It is interesting to note that not all students related to open-ended problem solving. According to Jean Piaget's cognitive theory, students ages 7 to 11 are in the "concrete operational stage [8]." Students are not all alike when it comes to their development, both physical and mental. Hence a good mixture of open-ended problems and rules-based, if/then types of scenarios would have increased the overall students' interest and engagement.

IV. Subtle Nudge and Encouragement to Female Students

We created flyers to advertise the camp to students. In the flyer, special attention was paid to the language, content, and imagery to provide subtle nudges to encourage female student participation. The image used for the flyer was of a female computer scientist guiding with a young female student keenly looking at her computer screen. The language used the construct "young women and men" to highlight the participation of women (Fig. 6). Also, throughout the sessions, the construct "she or he" was used in equal proportions to "he or she" to enforce the subconscious cues of equality.

Dr. Bushra Anjum will lead the camp, consisting of 5 highly interactive training sessions, to introduce various exciting computing concepts to the students. The sessions will include videos, active discussion, and hands-on activities to learn new skills that will ***help young women and men*** *to lead the future of technology.*

Dr. Anjum is originally from Pakistan and has taught and mentored internationally. She is currently working remotely for a San Francisco based startup as a Data Scientist.

Fig. 6. Text used for flyer

In each lesson, the examples of prominent figures were carefully chosen to highlight the contribution of one female and one male individual. For example, while discussing the history of computers and computer science, *Ada Lovelace* was mentioned alongside Charles Babbage. For the topic of internet and communication, *Radia Perlman's* spanning tree was referred to alongside Vint Cerf internet architecture. When the topic of security was discussed, the contributions of *Hedy Lamarr* for Frequency Hopping were examined along with the Caesar cipher by Julius Caesar.

It is paramount that female students identify with the pioneers of the field and see that women have been contributing to computer science since its inception. We conducted a survey 3 months after the camp to access the impact of these efforts. The results are in the next section.

A. Anectodal Evidence

The 12 girls were interviewed 3 months after the computing camp was offered. Mr. Wilcox utilized a qualitative questionnaire to analyze the aspect of interest effectiveness of the computing camp. A conceptual approach to understanding computer science was selected based on the rationale that understanding variables, expressions, and loops are foremost to most computer science careers [9].

Figure 7 contains the quotes from the girls in reference to the question: Do you think it made a difference having a woman computer scientist teaching Computer Camp? If so, how?

Overall, 6th grade student females responded positively to having a woman data scientist teach computer science.

CONCLUSIONS

The primary goal of the computing camp was to introduce the field of computer science to the students and the immense potential for good it holds. The secondary goal was to inform that programming is just a small part of computer science. The bulk of the work that computer scientists do is figuring out the right solution, which requires creativity, critical thinking and collaboration. We were able to achieve both these goals using interactive sessions, active discussions and hands on exercises. Further, we were able to spark female students' interest and curiosity about computer science by carefully choosing language, woman pioneer examples, and in person discussions.

We are also happy to report that a coding class is now incorporated in the 6th grade, in part due to the introduction to computer science via the computing camp. The new course introduces, and is built on, Scratch.

- *"Yes, 'cause it was more inspiring."*
- *"Yes because she would tell us that girls could also do anything, so yes."*
- *"Yes, so that more women will want to do that."*
- *"Yes, it showed women empowerment."*
- *"It showed the females in the group that they could have very important jobs."*
- *"Yes because she showed it from a different view point."*
- *"I think it made a difference having a woman computer scientist teach me because she showed her side on working in computer science. She also encouraged girls that computer science is a great field to work in. She shared experiences she has had."*

Fig. 7. Student feedback

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